<u>Lines in mill industry - flour production</u> sheet 71

Grain

- <u>floury kernel (endosperm)</u> – starch, proteins; is covered with an endospermal layer compounds of proteins and fats
- <u>germ (sprout)</u> – fats, sugars, proteins, active enzymes, vitamins B_1, E
- <u>covering layers (bran)</u> – cellulose, hemicellulose; protect germ and endosperm from dehydration and damage
- <u>grain contains</u> – c. 12 – 18 % of water; at the moisture is in inaction
- <u>grain quality</u> – is evaluated according to content of carbohydrates (starch, sugars, dextrin, cellulose, hemicellulose, pulp) and gluten (proteins insoluble in cold water)
- <u>gluten</u> – viscous and elastic matter; after wetting swells and forms an elastic lattice structure (net structure) → + CO_2 from dough proofing → elastic and porous dough structure; in wheat grain is c. 14 % of dry gluten

Grain milling

= Separation of floury kernel (endosperm) from covering layers and germ.

Work with a dusty material → all connections etc. of machines, hoppers, pneumatic handling etc. have to be closed (cloth sleeves) and grounded; electric-motors have to be flameproof.

Roller mill with two-pairs of rollers

sheet 75

1. grain (semolina) inlet
2. feeding rollers
3. grinding rollers – grooved for scraping or coarse milling
   - smooth for fine milling
   - gap and pressure are controlled
4. scrapping brushes
5. flour (semolina, pimple) outlet

High-speed roller is firm, low-speed roller is movable (gap and pressure control)
Rollers diameter is c. 250 – 300 mm, L ≈ 1000 mm, hardness is HB = 450 – 520
Speed ratio: high-speed roller/ low-speed roller = (3 – 7) / 1 (3 times higher revolutions)

Example:
For wheat groats (grit): a circumferential speed is c. 6 m/s, for capacity 2000 – 7000 kg/h is an electric-motor input c. 5,5 – 23 kW (for rye grit is the capacity c. half for the same electric input)

Plansifter

sheet76

Plansifter is used for classification of grist (flour) by means of plane sieves.
Plansifter is hanged on wooden (laminated) bars and eccentric drive oscillates it to a wheal motion.
The best flour is from the first milling (majority of endosperm), from next milling more particles of covering layers are in flour.

Flour extraction (yield from grain):
- c. 77 % flour + semolina
- c. 7 % shorts (flour for feeding)
- c. 15 % bran – for animal feeding
- c. 1 % sprouts (pharmacy), dust (feeding, compost)

Lines in bakery industry sheet 77

Flour quality: - according Czech standards flour moisture has to be ≤ 15 %
- fresh milled flour has to age else a dough is greasy and sticky, creeps and it does not heave (dough proofing)
- wheat flour ages 3 – 6 weeks, rye flour 1 – 2 weeks
- the higher flour temperature and moisture the shorter ageing time

Bread consumption in ČR is c. 36 kg/person/year, rolls and pastries c. 22 kg

Basic bakery products

- **Bread** – rye, wheat, combination, whole-bread; bread forms – loaf, roll, formed b.
- **White products** = rolls, French loafs (baguettes) …; with fat or without fat
- **Fancy cake** – cakes, Christmas cakes, Easter cakes, pies, strudels, stuffed cakes … with various filling
- **Confectionery** – tarts (fruit cakes), desserts, rolls …
- **Dry goods** – crumbs, biscuits (store-bread; for diet) …
- **Pastries** – spaghetti, noodle, ….

Line for bread production sheet 78

- Flour is stored in silos – there it aged
- After ageing is flour transported in a daily silo
- Silos outlets are aerated and vibrated → prevention of ”vaulting creation” during silos emptying

Leaven preparation (c. 20 h before 1st dough preparation)

1. **Base preparation** = crumble bread + rye flour + water; yeasts from old bread cause dough aeration (fleecy bread structure), bacteria typical taste; fermentation process is c. 8 h at 24 – 25 °C
2. **I. stage of leaven preparation** = prepared base + rye flour + water; fermentation process is c. 5 h at 24 – 25 °C
3. **II. stage of leaven prep.** = prepared I. stage of leaven + rye flour + water; fermentation process is c. 4 h at 25 – 26 °C
4. **III. stage of leaven prep.** = prepared II. stage of leaven + rye flour + water; fermentation process is c. 2,5 h at 27 – 28 °C
5. **The leaven is used the whole week as so called reproduced leaven** = 2/3 of the leaven is put in a kneader + rye flour + water + salt solution + event. ingredients (caraway seeds etc.); all components are mixed and kneaded to dough (in dough is c. 56 % of reproduced leaven, c. 32 % of flour and c. 12 % of water); the spare 1/3 of the reproduced leaven is refilled with flour and water for a new reproduced leaven preparation (for a next day).

Processes proceed during bread baking

sheet 80

- starches and proteins swell, yeast escalate activity, maximum is at c. 35 °C
- at c. 50 °C yeast begin to wither away (die down), starch begins to gelatinise and absorbs water, proteins loose water
- starch gelatinising is maximal at 80 °C, proteins coagulate → a firm bread "skeleton" (frame) is formed
- bread-crumb is during baking heated to c. 95 °C, crust to c. 170 – 190 °C
- at 100 °C starches begin to hydrolyse to dextrin, at 140 – 160 °C sugars begin to caramelise, fats and proteins change their nature too (denaturate) → newly arose matters give to the crust a special taste, smell, colour and glance

Processes proceed in baked bread

- after cooling bread contains c. 42 % of water
- water during storage evaporates from bread (1st day c. 3 %, next days c. 1 – 2 %)
- during storing and evaporating the amorphous gelatinised starch transforms to a starch with a crystallic structure = starch retrogradation
- water leaves bread-crumb (where was fixed in starch, proteins etc. structures) and goes to the bread surface = crust → the crust loses its crackling; proteins transforms too → bread quality deterioration

Bakery ovens – dividing, types

sheet 82

- **according baking area**

  - **peel ovens** – stationary baking area, dough is put in and bread taken off by the help of a spatula – an old bread ovens in which were a fire-place, but a new types with an electric or gas heating too
  - **pull-out ovens** – it is possible a baking area (baking tin) draw out from an oven (like home ovens)
  - **hanging plates ovens** – on 2 chains are hung ”benches” (plates) where is dough put and where is baked; inlet and outlet are usually at the same oven end (but in various heights)
  - **belt ovens** – the belt is from a wire-netting (screen); dough is put on the belt and during its moving through the oven is baked; bread outlet is at an opposite end than dough inlet

- **according type of operation**

  - **periodical** – peel and pull-out ovens
  - **running (continuous)** – hanging-plates and belt ovens

- **according a way of heating**

  - <u>**with direct heating**</u>

    - **furnace ovens** – old classic ovens; in a oven is fire and after some time when the oven is hot-heated ash is raked out and in the oven is dough put (wooden spatula)
    - **electric ovens** – electric heating

  - <u>**with indirect heating**</u>
    - **channel ovens** – heating medium (liquid = dowtherm, delotherm is heated outside the oven) flows through tubes or channels in oven's walls and heats baking space
    - **steam ovens** – steam condensing in tubes heats baking space
    - **cyclothermic ovens** – flue gas from a burner or fire-place flows through heating channels and heats baking space; part of chilled flue gases recirculates and is mixed with a hot flue gas → fan, fuel saving
    - **convective ovens** – baking space is heated by circulating hot air; heat transfer to dough is mostly by convection, partially by radiation from walls and conduction from baking plate → > baking uniformity, baking time is shorter

Small bakeries

sheet 83

- <u>**electric pull-in/out ovens**</u> – dough can heave there and after it it is baked → temperature is controlled from 30 to 350 °C, possibility to wet working room, possibility of 2 working rooms (heaving, baking) separately controlled; specific output 10 – 20 kg/m^{2}h

- **<u>batch type convective ovens</u>** – dough is put on plates like above but there is a fan for hot air circulation (temperature field is more uniform, higher α = heat transfer coefficient $\rightarrow$ shorter baking time, higher product quality)

Big bakerhouses

- **<u>continuous belt ovens</u>** – belt with width till 3 m, length till 50 m
  - drawback – very long and low oven
  - majority of flue gas (steam, heating liquid) flows in channels under the belt = <u>lower heat</u> (the belt has to be heated and because hot air flows up)
  - minority of flue gas etc. flows in channels above the belt = <u>upper heat</u>
  - heat of leaving flue gas is used for combustion air preheating, part of flue gas recirculates, the rest is used for other heating purposes in a bakerhouse
  - front section of the oven (c. 25 – 30 % of an oven area) has consumption c. 50 % of a total heat, rear section has < heat consumption
  - specific output is till 20 kg/m^{2}h (for bread or rolls)

- **<u>hanging plates oven</u>** – ”benches” (plates looking like stretchers) with width till 3 m hung on 2 drag-chains
  - shorter and higher oven (lower ground area)
  - more complicated flue gas and/or air flow in such oven
  - dough inlet and bread outlet is on the same oven side $\rightarrow$ may be problems with manipulation and hygiene

Extrusion

sheet 84

- Physico-chemical process when materials (starches, proteins) change their structure (to a ”frothing” structure)

- Material inlets to an 1 or 2 worm(s) extruder; rotating worm(s) moves it to the other end where is smaller volume → pressure and temperature of material increase (till c. 10 MPa and 200 °C); material is intensively mixed, starch becomes gelatious, proteins denaturate (semi-liquid state of material, plasticising)
- When the material outlets from a nozzle to an open air it becomes superheated and steam leaves the material → a typical porous structure rises
- Extruders are without or with heating (if a transformation of worms mechanical energy to heat is not sufficient)
- Extruded material is modified according needs – pressing rolls → needed thickness, cutting, surface finishing (flavours, sauce …..), roasting, drying, cooling, packaging …

Lines for starch production

sheet 85

- Wheat starch was used as early as 3500 years B.C. in cosmetics, paper production and medicine
- Technology of a starch separation was described by Cato (c. 200 y. B.C.) – wheat milling, grist mixing with water, fermenting, washing of arose dough, drying → product was a starch powder = amylum
- Analogous was a starch production from rice etc.
- A first factory for starch production was in the U.S.A. in 1707 (from corn (maize))
- In the 18th century was in Europe starch produced from potatoes
- From the 19th century are produced so-called modified starches, starch derivates (+ chlorine, hydrogen peroxide, sodium peroxide, formaldehyde …)

Starch and its properties

- Starch = a mixture of 2 polysaccharides (20 % of amylose and 80 % of amylopectin) organised in a complicated structure
- It is a white powder in cold water insoluble, enzymes do not act on it in the state

- When is water-starch dispersion heated above 60 °C (temperature of gelatination) starch particles swell up, crack and starch molecules dissipate from particles to water; enzymes can act to the gelatinous starch

Saccharides

- <u>**Monosaccharides**</u>
  - **glucose (grape sugar) – $C_6H_{12}O_6$** (aldehydic group CHO)
  - **fructose (fruit sugar) – $C_6H_{12}O_6$** (ketonic group CO)
  - xylose, mannose, galactose …
- <u>**Oligosaccharides**</u> (2 – 10 connected monosaccharides)
  - **saccharose** (sucrose, beet or cane sugar) = glucose + fructose – $C_{12}H_{22}O_{11}$
  - **lactose** (milk sugar) = glucose + galactose - $C_{12}H_{22}O_{11}$
  - **maltose** (malt sugar) - $C_{12}H_{22}O_{11}$ (other molecular structure)
- <u>**Polysaccharides**</u> (> 10 connected monosaccharides)
  - **amylose** – is compound of maltose units, in water is soluble
  - **amylopectin** – is compound of glucose units $(C_6H_{12}O_6)_n$, in water is insoluble
  - **dextrins** – on a glucose basis
  - **inulin** – on a fructose basis ...... and many of various others types
  - **cellulose** – the biggest molecules – cell walls, supporting tissues

Starch is made from potatoes, wheat, maize (corn), rice, manioca ….

(in ČR in 1994 was price of potatoes starch c. 15,- Kč/kg
price of wheat starch was c. 8,- Kč/kg)

Potatoes starch production

- the best quality but the most expensive production
- potatoes with high starch content and resistant to infections was cultivated
- campaign production

- potatoes dry matter losses in waste water are till 25 % → charge for environment
- world capacities are 1400 – 3600 t/d of potatoes, in ČR only 500 – 1000

Maize starch production

- special maize sorts were cultivated (for example with 100 % of amylopectin or with 100 % of amylose etc.)
- technology is practically perfect
- the cheapest production, biggest capacities, year-long production

Wheat starch production

- special wheat sorts were cultivated (starch content, gluten content, yield …)
- technology is similar like for maize
- starch quality is a bit worse

Starch production and its processing is a quick developing branch of industry

Potatoes starch production

sheet 87

Potatoes contains c. 76 % of water and c. 15 – 18 % of starch (a rest are proteins and cellulose etc.).
Starch granules are closed in potato cells. They are released by grating. Released starch granules are separated from pulp and proteins by washing and sedimentation. A starch refining (purification) is done by washing and sedimentation processes. Then is starch dried, milled and sifted. In the process are mostly used hydro-mechanical processes.

Starch milk refining (purification) and processing

- **Pulp separation**

  Starch milk contains water, starch granules and a small quantity of very fine pulp. The pulp is separated by filtration or sedimentation processes → vibrating purifying sieves, curved sieves or washing centrifugal machines (type Starcosa)

- **Starch milk concentration**

  - quiet milk sedimentation ↕ vessels, mangers, chamber traps
  - flowing milk sedimentation in old factories
  - starch sedimentation in hydrocyclones ↕ in new factories
  - starch sedimentation in centrifuges

- **Starch washing**

  - starch in a starch milk is not clear → it is washed with fresh water in mixed vessels (volume c. 3 – 8 m^3 + stirrer)
  - after c. 1 h of mixing is the stirrer lifted from the vessel and the mixture sediments c. 10 h (several sedimentation layers forms; from bottom up = sand, bigger and finer starch granules, fine sludge + coagulated proteins)
  - the layers are separated by a special draining and the washing is repeated
  - settled starch is mixed with water to starch milk with concentration c. 50 %

- **Starch dewatering**

  - 1° mechanically = filter horizontal centrifuges, semiautomatic (shell from a perforated plate + sieve) or vacuum filters
  - 2° drying to c. 10-20 % of moisture (starch temperature has to be < 40 °C to avoid a starch gelatinising – heaving); <u>dryers</u>: drying hurdles in chamber

dryers, tunnel dryers, disc dryers, flow dryers, fluidised-bed dryers …

Flow sheet of potatoes starch production

sheet 88

potatoes potatoes reception place

↓

water → **storage** storage place

↓ potatoes

water → **potatoes cleaning, weighing** → catchers, washers like in sugar factory

↓ sand, stone, leaves separ. – 10 – 30 %

↓ potatoes

water + → **potatoes grating** grater, desintegrator

0,03 % of H_2SO_3 → ↓

per grated potatoes ↓ pulp (grist) (sulphurous acid – starch white colour, micro-organisms)

water → **pulp washing and separation** → waste water sieves, centrifugal machines

↓ washed pulp starch milk

water → **pulp re-grating** grater, desintegrator

H_2SO_3 →

↓ washed pulp

water → **pulp re-washing and separation** → waste water + pulp sieves, centrifugal machines

↓ starch milk 2,0 – 2,5 °Bé

water → **starch milk purification** → fine pulp vibrating sieves

↓ starch milk

starch milk concentration → water hydrocyclones, centrifuges

↓ starch milk c. 15 – 20 °Bé (50 % D.M.)

water → **starch milk washing** → fine pulp etc. mixed vessels

↓ starch milk

starch milk filtration → water centrifuges, filters

↓ wet starch

hot air → **starch milk drying** → air + vapour dryers

↓ dry starch

starch treatment (milling, sifting, expedition) mill, plansifter …

↓

dry starch

Some technologic data:

Pulp (třenka) = starch granules (c. 10 %) + potatoes water + grated tissue + added water + proteins + small amount of sulphurous acid.
Washed pulp (zdrtky) = pulp without majority of starch granules.

Water consumption is c. 8 – 10 m^3 / t of potatoes.

Flow sheet of potatoes starch production – an old system

sheet 89

1. potatoes reception and storage
2. potatoes pump
3. potatoes washer
4. bucket elevator
5. scale
6. bunker
7. grater (desintegrator)
8. hole for pulp
9. pulp separator
10. 1° of washing
11. re-grater
12. 2° of washing
13. pulp-press
14. pre-refining vibrating sieve
15. starch milk and pulp separator
16. refining vibrating sieve
17. refining settlers (alternatively)
18. mixed tank with circulation
19. mixed tanks – settlers
20. tank for concentrated starch milk
21. vacuum filter
22. filter centrifuge (alternatively)
23. starch disc dryer
24. plansifter
25. starch expedition

Flow sheet of maize starch production (simplified)

sheet 92

maize 100 kg

↓

storage + cleaning — silos etc.

↓

water from technology → **steeping** → steeping water — steeping tanks

H_2SO_3 (sulphurous acid) ↓ concentration in film evaporator

↓ + drying c. 6 kg

raw starch milk ← **grinding and sprouts separation** — disintegrators, hydrocyclones

→ sprouts

↓ pressing, drying → oil, feeding c. 8 kg

↓

fine milling mills

↓

raw starch milk ← **peels separation** → peels sieves

↓ milling, pressing, mixing, drying – pulp c.10 kg

→ **gluten separation** → gluten water filters, centrifuges

↓ settling, evaporating, drying

↓ gluten = protein from maize c. 6 kg

water → **starch washing** → water mixed vessels, centrifuges ...

→ **liquid starch**

hot air → **starch separation** → water
and drying → air + vapour

↓

dried starch c. 70 kg

Wheat starch production is similar.

Water recirculation (lower water consumption): waste water cleaning, pasteurisation, SO_2 adding ($H_2O + SO_2 \rightarrow H_2SO_3$; starch white colour + micro-organisms killing) → < water consumption (warm close method in an acid media).

Waste water treatment

sheet 93

Waste water quantity in old starch factories is c. ≤ 1000 % of treated potatoes; now economical technologies are used with multiple water using x problems as the water contains organic matter, salts etc., decays, froths …

Ways of treatment:

- fields irrigation – acceptable for small factories (soil salinisation ….)
- ponds with or without turbine aerators

- waste water treatment plans (3 stages – mechanical + anaerobic + aerobic – see sugar factory)
- membrane filtration → water back to technology, sludge to w.w.t.p. (ČOV), concentrating, drying (→ feeding for animals – pigs, cattle)
- concentrating, evaporating, drying → feeding or fertiliser (? desalination)

Starch treatment

- **Hydrolysis in water = long starch molecules splitting to smaller ones**

  starch = polysaccharides → monosaccharides glucose + fructose = substitutional sweeteners

  degree of saccharification (Dextrose Equivalent) DE = 100 % - only pure glucose and fructose are in product

  - **acid hydrolysis** - hydrochloric acid, sulphuric acid, oxalic acid … + temperature + pressure → molecules splitting, neutralisation, cleaning, concentration

    G-F syrups DE ≈ 30 – 55 % (30 – 50 % of starch transforms to glucose

    and fructose)

  - **combined hydrolysis** – after acid h. follows saccharification catalysed by an enzyme amylogucosidase → inactivation, filtration, cleaning, concentration; DE = 93 – 94 %

  - **enzymatic hydrolysis** – a starch saccharification and liquefying by the help of enzymes amylase and then amylogucosidase → inactivation, filtration, cleaning, concentration; DE = 96 – 98 %

- **C. 50 % of world's starch production is used for sweeteners production**

- **<u>Products from starch</u>**

  - **G-F syrups = glucose-fructose syrups** → sweeteners with the same sweetening effect like sugar but with lower energetic content + better for digestion
  - **crystallic glucose** – for medicine
  - **maltose syrup** – candies production
  - **technical dextrines** – textile industry, additives to paints ….
  - **malto-dextrines** – clear solution, soluble at cold state, without any taste (for medicine, diets, lemonades, ice-creams, meat industry, processed cheeses production, durable pastry …..)
  - **starch and dextrine glues -** starch latex, dextrine-latex glues – biodegradable material
  - **modified starch** – a special treatment ensures required and defined properties of a product
    - *<u>in food industry</u>* – extruded products, cereals, instant flours, additives to pastries, special nourishment ….
    - *<u>in civil engineering</u>* – bonding compounds in mortar made from fly-ash
    - *<u>in geology</u>* – material that is plastic at very high shear stress

<u>Edible oils and spreads production</u> sheet 95

<u>Fats (lipides) = compounds of fatty acids</u>, fixed to a glycerine molecule

- **Fats are insoluble in water**
- **According a way of fixing of adjoining carbon atoms fat acids are divided to:**
  - *<u>saturated fat acid</u>*: bond C – C; animal fats, cholesterol, infarct, arteriosclerosis …

- *unsaturated fat acids*: bond C = C; vegetable oils (fats)

- **Molecule size and carbon fixing determine fat property**
    - *liquid at normal temperature* – unsaturated, short molecular chain
    - *solid at normal temperature* – saturated, long molecular chain
    - for the same degree of saturation is a fat with a longer molecule chain stiffer

Sources of oils and fats

sheet 96

- **animal fats = lard** …
- **vegetable oils = vegetable seeds and fruits**
    - rape seed – Europe
    - sunflower seed – Europe
    - soybeans
    - olives – south Europe
    - maize sprouts
    - palm nuts (coconuts, copra)
    - peanuts
    - cacao beans

Vegetable oils are used in food industry, cosmetics, pharmacy, technology (lubricants, fuels, hydraulic oils – ecological).
A cultivation provided plants with required raw material properties and consequently of produced oil too (health, nutritive, technological etc. aspects)

Oily seed (fruit) contains from:

- oily part – cultivation is able to affect quantity and quality
- proteins part – cultivation is able to affect quantity and quality, forage-cake (fodder)

<u>Oil is from seeds (fruits) gained by:</u>

- **pressing, squeezing** – the oldest method – best quality (virgin oil), lower yield
- **extraction** – presently used – higher yield

<u>In ČR is wide-spread oil production from rape-seed and sunflower seed</u>

Varieties with lower content of erucic (lauric) acid (causes worse oil properties) and linolenic acid (causes lower oil thermal stability) and higher content of linoleic acid (higher oil quality) were cultivated.

Table oil or spreads production sheet 97

- raw oil production
- refining of raw oil – refined oil production – table oil
- stiffening of refined oil – spreads, margarine etc. production

Table oil production from soy – approximate balance

Inlets raw material:	- 1000 t/d of soybeans (18 % of oil, 12 % of water)
Products:	- 169 t/d of raw oil
	- 600 t/d of proteins concentrate (85 %)
	- 7 t/d of raw lecithin
	- 80 t/d peelings
Storage:	- silos capacity c. 80000 – 90000 t (for 90 days production)
Beans cleaning:	- screening, sifting, irons removing
Beans preparation:	- crushing, peels separation, tempering, milling to grist
Oil extraction:	- grist extraction, miscella (= solution of oil in solvent

(hexane, petrol)), miscella distillation (solvent recovery and oil separation), extracted grist stripping (recovery of solvent from grist)

Oil cleaning: - phosphatides separation, dewatering, cooling → raw oil

Raw oil refining: - washing, bleaching, desodoration → table oil

Grist treatment: - for animal feeding or soy flour production (from milled soybeans with peels (hulls), or from stripped grist), soy proteins for adding to meat products (soy proteins are cheaper than animal ones)

By the reason of better table oil quality rape seed + sunflower + soy oils are mixed together.

Flow sheet of edible oil and spreads production

sheet 98

Pressing can separate till 80 % of oil from seeds (fruits). Press is till 200 MPa, temperature till 160 °C.

In soybean oil is c. 25 % of proteins and 3 % of phosphatides, in rape seed oil is c. 55 % of proteins and 1,2 % of phosphatides.

Soap-stock is soluble in water but not in oil → water + NaOH solution adding (raw oil neutralisation and soap-stock centrifuging)

Bleaching clay absorbs colour impurities and then is separated (filtration)

Deodorization = bad smell separation by processes of oil heating and stripping

Tempering pan sheet 99

Function and purpose: - small oil droplets coagulation in bigger ones

- proteins denaturation → better oil and grist separation (yield)

Bleaching sheet 101

Bleacher work:

- Bleacher filling with oil mixed with bleaching clay (temperature c. 70 – 80 °C)
- Decompression to 0,01 MPa
- Heating up to c. 100 – 110 °C
- Holding time c. 30 minutes
- Underpressure release to a barometric pressure
- Oil pumping to a filter where bleaching clay with colour impurities are separated

Semi-continuous desodoration sheet 102

Goals: - Bad smell and taste compounds separation; they cause an oil inedibility (uneatable); their amount is only 0,001 – 0,01 %

Principle: - distillation – volatile compounds evaporate and are drawn off with a stripping steam in a desodorator

- temperature is c. 220 – 240 °C, pressure c. 460 Pa (= vacuum)
- oil is on plates (floors) hold for some time (20 – 30 min. → semi-continuous process) and then is passed down to a lower plate where is the process repeated
- stripping steam is injected directly to oil and so helps to volatile compounds separation

Stiffed fats (margarine) production sheet 103

- First margarine was developed in 1870 as a substitute (ersatz) of butter during Prussian – Austrian war
- Advantages: less cholesterol, saturated fat acids, good spreading at low temperature, cheaper than butter

Oil hydrogenation

= an oil saturation with hydrogen = change of double bonds of carbon (unsaturated) to single bonds (saturated) – an example for an oleic acid saturation to a stearic acid:

```
       oleic acid                          stearic acid

     H   H   H   H                      H   H   H   H
     |   |   |   |                      |   |   |   |
R – C – C = C – C – R       ⇒      R – C – C - C – C – R
     |           |                      |   |   |   |
     H           H                      H   H   H   H
```

Hydrogenation steps: continuous, discontinuous (batch)

- reactors 5 – 20 m^3, mixer, heating (cooling) coils
- oil filling, heating to c. 50 °C, hydrogen adding for an air drawing off from oil
- catalyst adding (powdered Ni c. 0,1 – 1 % mass)
- heating to c. 150 – 160 °C, hydrogen is supplied in oil (c. 20 – 50 m^3 / t of oil), pressure c. 200 – 300 kPa (maybe 1,5 – 3,0 MPa too → quicker process), hydrogen has to be perfectly dispersed in oil (saturation of all molecules, good yield)
- exothermic reaction → cooling – mixture heats up to c. 180 °C for margarine and to c. 200 – 220 °C for fats for technical purposes
- non reacted hydrogen is cleaned and flows back to a gas-holder (better H_2 exploitation)

- during hydrogenation are samples of fat taken off for melting point testing → determination of hydrogenation end
- fat cooling below 100 °C
- perfect filtering off Ni from stiffed oil (Ni is a poison), centrifuging
- stiffening time is c. 3 – 6 h (for higher press is lower)

Fat can be sprayed in hydrogen too (= contrary of the process described above where was hydrogen injected in oil).

Composition modification

The stiffed fat is mixed with vegetable oils, dried milk, water, vitamins, emulsifiers, flavours ….. → spread fats etc.