Fine Food Production

White Paper

Table of Contents

Gerstenberg Schröder®

EXECUTIVE SUMMARY

Food companies today are like other manufacturing businesses not only focusing on the reliability and quality of the food processing equipment but also on various services which the supplier of the processing equipment can deliver. Apart from the efficient processing lines we deliver, we can be a partner from the initial idea or project stage to the final commissioning phase, not to forget the important after-market service. SPX Flow Technology has Gerstenberg Schröder installations in more than 110 countries around the world.

INTRODUCTION TO SPX FLOW TECHNOLOGY

VISION AND COMMITMENT

SPX's Flow Technology segment designs, manufactures and markets process engineering and automation solutions to the dairy, food, beverage, marine, pharmaceutical and personal care industries through its global operations.

We are committed to helping our customers all over the world to improve the performance and profitability of their manufacturing plant and processes. We achieve this by offering a wide range of products and solutions from engineered components to design of complete process plants supported by world-leading applications and development expertise.

We continue to help our customers optimize the performance and profitability of their plant throughout its service life with support services tailored to their individual needs through a coordinated customer service and spare parts network.

CUSTOMER FOCUS

SPX Flow Technology develops, manufactures and installs modern, high efficient and reliable processing lines for the food industry. For the production of crystallized fat products like margarine, butter, spreads and shortenings SPX offers Gerstenberg Schröder solutions which also comprise process lines for emulsified food products such as mayonnaise, sauces and dressings.

INTRODUCTION TO FINE FOOD

Fine food products, such as mayonnaises, dressings or sauces, mainly consist of an oil phase, a water phase and an emulsifier. Both phases form an oil-in-water emulsion after mixing.

- continuous phase: water
- dispersed phase: oil drops

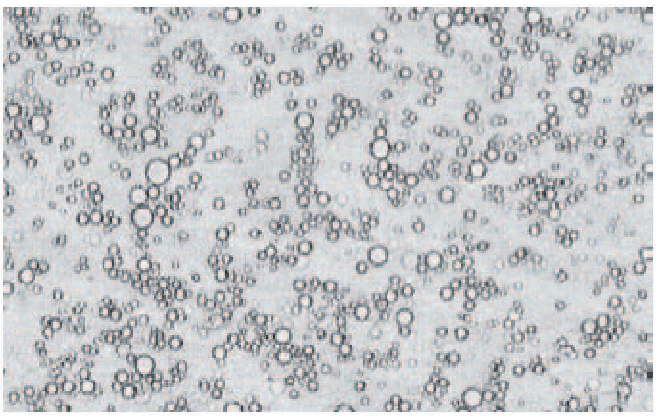
The emulsifier is used for the stabilization of the boundary layers by decreasing the surface tension.

The size of oil drops in the emulsion determines the product quality to a large degree; for lower fat versions mayonnaise the stability of the water phase also has a large influence on the quality. Apart from the mechanical and microbiological stability, also the size of the oil drops and their distribution in the emulsion play an important role.

For mayonnaise with a low oil content the viscosity is determined by the size of oil drops (generally 5 - 7 µm) as well as by the amount and type of stabilizers (starch, hydrocolloids) which have been used to stabilise the continuous water phase.

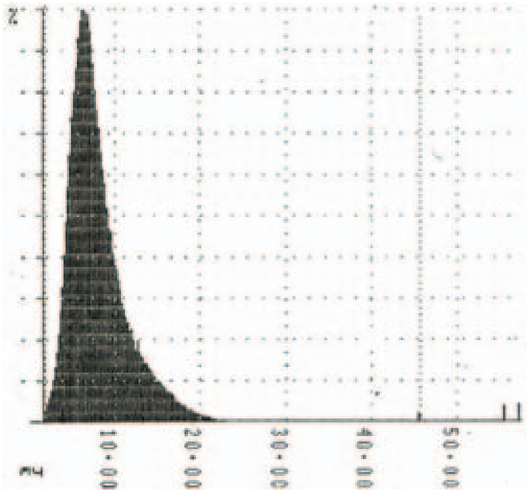
Microscopical tests of oil drop size and distribution have been conducted on products which have been successfully produced in our processing plants. These microscopical tests have shown that the products have a very fine distribution of the oil drops.

In general, a high oil content will result in a narrow oil drop distribution and vice versa. The graphical evaluation of a mayonnaise with 67% oil content revealed a maximum distribution of oil drops of 5-6 µm (pictures 1 and 2). In a mayonnaise with 80% oil content the maximum oil drop distribution was 3-4 µm.

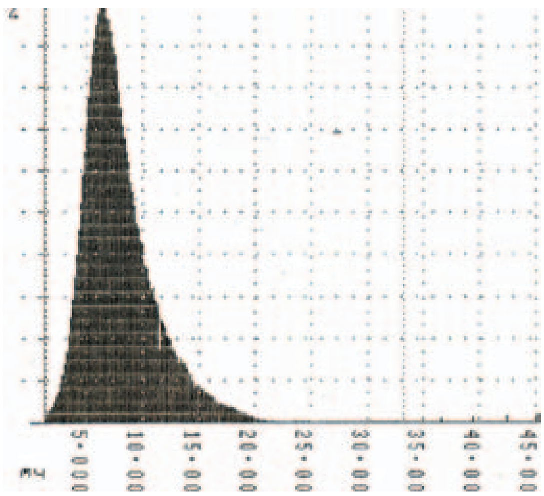


Picture 1: Distribution of oil drops in a mayonnaise with 67% oil content

These results have also been confirmed during storage stability tests of the emulsion. There were no significant differences in the distribution of oil drops shortly after production compared to the simulated storage test (picture 3). Therefore, the end product exhibits a very good physical long term stability and consequently long-lasting product stability.



Picture 2: Distribution of oil drops after production (mayonnaise with 67% oil content)



Picture 3: Distribution of oil drops after storage test (mayonnaise with 67% oil content)

RAW MATERIALS

Information on the raw materials and mixtures used for the production of mayonnaise is shown in the table below. All data are estimated values and can vary depending on the composition of the phase.

MEDIUM	DESCRIPTION	VISCOSITY (CP)	DENSITY (KG/L)	STORAGE TEMP. (°C)
WATER	-	1	1.000	10-15
OIL	VEGETABLE OIL	100	0.920	10-14
VINEGAR	VINEGAR 10%	1	1.000	10-15
EGG YOLK	TECHNICALLY PURE EGG YOLK WITH 10% SALT	2,000-3,000	0.810-1.100	≤5
WHOLE EGG	EGG YOLK AND WHITE IN THE RATION OF 1:2, OR NATURAL	800-1,500	1.020	≤5
STARCH/WATER WITH STABILIZER	WATER, STARCH POWDER (WARM SWELLING STARCH), STABILIZERS, ETC.	500-1,500	1.010-1.040	10-18
STARCH/WATER WITHOUT STABILIZER	WATER, STARCH POWDER (WARM SWELLING STARCH), ETC.	200-450	1.010	10-18
SPICE MIXTURE WITH STABILIZER	WATER, VINEGAR, MUSTARD PASTE, SUGAR, SALT, ETC.	1,000-2,000	1.010-1.020	10-15
SPICE MIXTURE WITHOUT STABILIZER	WATER, VINEGAR, MUSTARD PASTE, SUGAR, SALT, ETC.	500-700	1.010-1.020	10-15

Raw materials and mixtures used for mayonnaise production

MAYONNAISE RECIPE

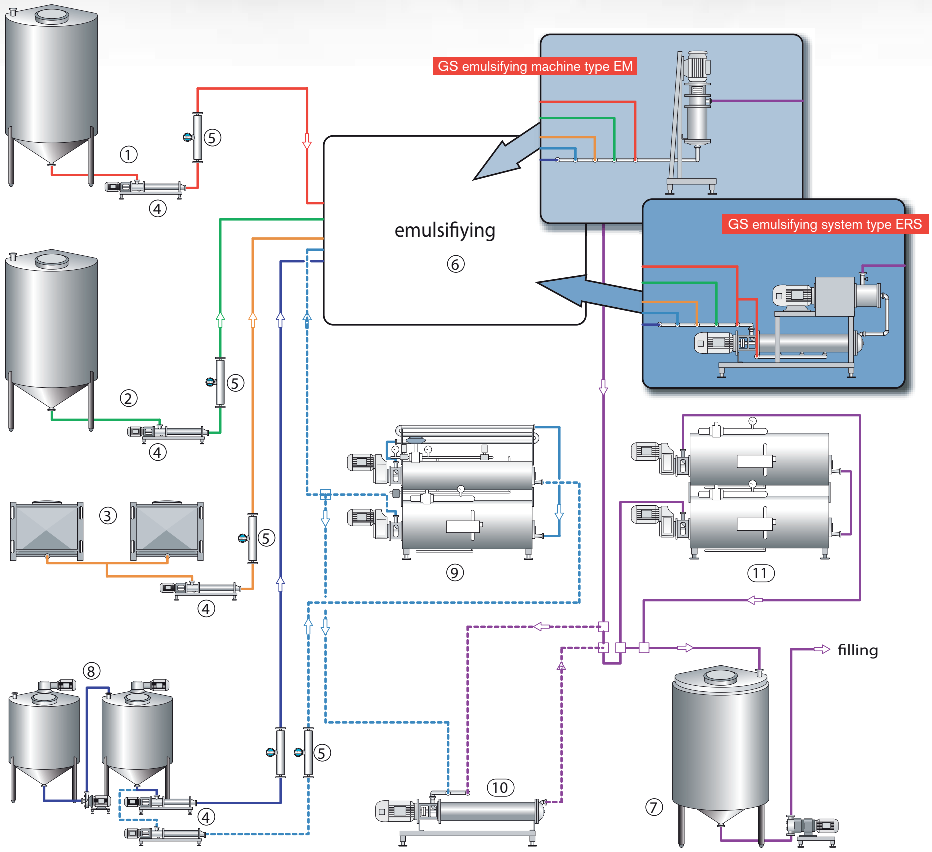
From region to region recipes for mayonnaise differ. The difference in e.g. the use of emulsifier system has an impact on the viscosity of the final mayonnaise. Egg powder dissolved in water is used in Russia, egg yolk is used in Europe while in South America an egg mixture consisting of egg white and egg yolk is normally used. The egg yolk phase can be replaced by other emulsifiers such as milk proteins. In South America, 5 phases are often used where the 5th phase (an oil phase) is used for dissolving color and flavor. Nitrogen can also be added in order to achieve a shorter structure. In addition, in some countries mayonnaise is sold by volume and not by weight.

Normally, continuous production of mayonnaise consists of 4 phases (oil, egg yolk, vinegar and water/starch). Typical recipes with 4 phases from Europe are shown in the table below:

PHASES	RAW MATERIAL	80%	65%	50%	30%
1. OIL PHASE	OIL	79.0	64.0	49.0	29.0
2. YOLK	YOLK INCL. 10% SALT	6.5	4.5	3.5	2.5
3. WATER/VINEGAR	WATER	4.0	-	-	-
	VINEGAR 10%	-	4.0	4.0	4.5
4. STARCH/WATER	WATER	4.0	19.2	33.5	50.3
	STARCH	-	1.9	3.2	5.2
	SALT	-	0.9	1.0	1.2
	SUGAR	2.5	2.8	3.0	3.5
	STABILIZER	-	0.1	0.1	0.2
	VINEGAR 10%	3.5	-	-	-
	SOYBEAN OIL*	-	0.2	0.3	0.6
	MUSTARD	2.0	2.5	2.5	3.0

* in order to facilitate in-mixing of the stabilizer

PROCESS FLOW



raw material/preparation area · dosing · heat treatment/emulsifiying/mixing · product buffering

1 - storage tank for edible oil
2 - storage tank for vinegar
3 - egg yolk container
4 - conveying pump
5 - mass flow meter
6 - emulsifying system
7 - product buffering tank
8 - preparation water phase
9+11 - GS Consistator® MD*
10 - GS product mixer type PM*

* OPTION

Picture 4

The modular structure of the production line for fine food results in optimal flexibility. The continuous line offers the possibility of manufacturing a wide range of products as the processing parameters of the GS ERS system can easily be altered or adapted during processing. By altering the processing parameters such as the rpm of the emulsifying machine type EG or the rpm of the visco rotor (VR), the same recipe can result in different consistencies of the final product. The existing modules are configured in such a way that they can easily be integrated in a new process. Hereby, the original investments will remain, and necessary new investments are reduced to a minimum.

In addition, change of the original configurations of the plant is possible. E.g. concurrent production of mayonnaise not containing the starch phase (approx. 80% oil content) and production of ketchup or a sauce is possible.

When mayonnaise is produced, the different phases are dosed continuously into the emulsifying system in a recipe-controlled proportion in order to achieve optimal mixing of the ingredients. Two different GS emulsifying systems are available, GS emulsifying system type ERS and GS emulsifying machine type EM.

The GS emulsifying system type ERS consists of an emulsifying machine type EG and the VR (a colloid mill). The EG is used for the production of a pre-emulsion (process step 1). In the following VR high shear treatment is applied to the pre-emulsion in order to achieve a fine and homogeneous distribution of oil drops (process step 2).

The GS emulsifying machine type EM combines the process steps 1 and 2 just explained in one machine. The raw materials added circulate repeatedly in „loops“. This process offers low investment costs compared to the GS ERS system.

The different phases are added individually into the cylinder when produced by the GS ERS system. During start-up a certain

GS emulsifying machine EM

GS emulsifying system ERS

amount of the egg phase is added first followed by the oil and water phases. The oil phase can be divided into two or three additions depending on the capacity and product specification. Finally, the vinegar phase along with the oil phase with color and flavour is added. Nitrogen can be added in the last part of the EG.

Subsequently, the emulsion passes through the VR to get the fine oil drop distribution. The size of drops is affected by the gap size and the rotational speed of the VR. The viscosity and the stability of the final product again depend on the size of oil drops. Smaller oil drops give a higher viscosity and better stability in general according to Stokes' law. In general, the following processing parameters for GS emulsifying system ERS are recommended:

GS emulsifying system ERS:

MACHINE TYPE	PARAMETER	FULL FAT MAYONNAISE	LOW FAT MAYONNAISE (GLASS TYPE)	LOW FAT MAYONNAISE (BUCKET TYPE)
GS EMULSIFYING MACHINE (EG)	RESIDENCE TIME [S]	30	20	20
	TIP SPEED [M/S]	7.5-8.5	7.5-8.5	10-11
VISCO ROTOR (VR)	RPM [1/MIN]	1,500-1,850	1,000-1,200	600-1,000
	GAP SIZE [MM]	0.1-0.4	0.6-0.9	0.9-1.2

If the GS emulsifying machine EM is used, the following parameters are recommended:

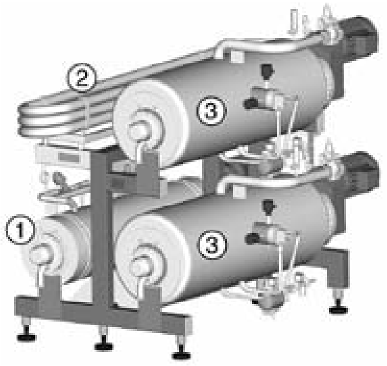
GS emulsifying machine EM:

MACHINE TYPE	PARAMETER	FULL FAT MAYONNAISE	LOW FAT MAYONNAISE (GLASS TYPE)	LOW FAT MAYONNAISE (BUCKET TYPE)
GS EMULSIFYING MACHINE (EG)	RPM [1/MIN]	1,300-2,150	900-1,800	600-1,500

PROCESS OPTIONS

Heat treatment of starch

Fine food products with reduced oil content often contain hot swelling starch. Thus the water phase needs a heat treatment before emulsification in order for the starch to swell. The SSHE GS Consistator® LD or GS Consistator® MD is ideal for this process.



In the GS Consistator® the phase is heated (1) to the required temperature, kept at this temperature (2) in the holding cell for a given time and subsequently cooled (3) to the specific processing temperature. The GS Consistator® system ensures an optimal swelling process of starch and offers a constant quality of the final product. In addition, the heating process has a pasteurization effect, e.g. for dressings containing vegetables or for ketchup-based products.

Mixing

In order to produce fine food products with ingredients containing particles (e.g. vegetables), a mixer type PM is used optionally after the emulsifying system. With this, basic mayonnaises with high viscosity, for example, can be mixed continuously with smaller vegetable ingredients in a homogeneous manner.

MAYONNAISE COOLING

If desired, the mayonnaise can be cooled to 2-6°C in a GS Consistator® LD or GS Consistator® MD before filling. The minimum temperature depends of the recipe and the temperature of the cooling medium. The following parameters are critical for the quality of the mayonnaise after cooling:

- Mechanical treatment
- Temperature of the refrigerant
- Final product temperature

If the mechanical treatment is too intense or the temperature of the refrigerant and product is too low there is a risk that the mayonnaise emulsion will destabilize. The optimal processing parameters depend on the recipe due to the great variety in stability of the final mayonnaise.

Mayonnaise cooling is desirable when mayonnaise is used in different kinds of salad (prawn, chicken or potato salad etc.). In addition, the cooling process saves cooling time in the subsequent cooling storage.

PROCESS OPTIMIZATION

Processing parameters depend on the raw materials, the recipe and the desired product properties.

In the table below recommendations regarding optimization of the mayonnaise manufactured by the GS ERS process can be seen. The recommended actions are quite similar for the GS EM system.

'The viscosity of the mayonnaise is too low, often due to an oil drop size which is too large'

Mayonnaise 67-80%:

- Reduce the gap of the VR in steps of 0.1 mm until the minimum gap is reached.
- If the desired viscosity is still not achieved, increase the rotational speed of the VR in steps of 100 rpm.

Mayonnaise 20-67% (glass type):

- Increase the rotational speed of the VR in steps of 100 rpm until a maximum of 1200-1300 rpm is reached.
- Reduce the gap of the VR in steps of 0.1 mm until a minimum gap of 0.6 mm is reached.
- At the same time, run a microscopical analysis of the starch to control the swelling of the starch.

Mayonnaise 20-67% (bucket type)

- Increase the rotational speed of the emulsifying machine (EG) in steps of 100 rpm until a maximum of 1,100 rpm is reached.
- *In most cases the viscosity of this product is very high due to a high amount of native starch. It is not advisable to increase the speed in the VR because it will break down the starch particles.*
- Increase the gap of the VR in steps of 0.1 mm until a maximum of 1.2 mm is reached (only for products with a high amount of starch).
- *In general, an increased gap size will result in larger oil drops due to less shear, but with addition of a high shear rate the emulsion breaks because the starch particles are destroyed.*
- At the same time, run a microscopical analysis of the starch to control the swelling of the starch.

PROCESSING PLANTS FOR EVERY CAPACITY RANGE

The capacities indicated in the table below refer to production of mayonnaise with an oil content of 80%. In general, the capacity will be approx. 33% higher for low fat mayonnaise due to a shorter residence time requirement in the equipment. The rule of thumb states a residence time of 30 seconds for 80% mayonnaise and only 20 seconds for 50% mayonnaise. The finished mayonnaise is often evaluated based on the following criteria:

GS EMULSIFYING SYSTEM	50-100 KG/H [1]	375-750 KG/H	750-1,500 KG/H	1,750-3,500 KG/H	3,500-7,000 KG/H	5,000-10,000 KG/H	7,500-15,000 KG/H
EM 100	▪						
EM 750		▪					
EM 1,500			▪				
EM 3,500				▪			
ERS 100	▪						
ERS 1,500			▪				
ERS 3,500				▪			
ERS 7,000					▪		
ERS 10,000						▪	
ERS 15,000							▪

1) Capacity range for pilot plants

EVALUATION OF FINAL PRODUCT

The finished mayonnaise is often evaluated based on the following criteria:

- Viscosity and oil drop size
- Broad variety in viscosity from recipe to recipe (50,000-500,000 cP)
- A good full-fat mayonnaise typically has a particle size of 3-4 µm
- Important for shelf life and taste
- Finally, pH determination is also used as a process control
- Shelf life
- Microbiological
- Stability of the emulsion is directly associated with the viscosity and the oil drop size and distribution
- Sensory characteristics
- Taste
- Mouth-feel

ADVANTAGES OF THE CONTINUOUS FINE FOOD PROCESS

- Constant and automated recipe control of dosing accuracy with possibility of easy modification of product appearance by adjustment of processing parameters during actual production.
- Constant and reproduceable quality level of the final products in terms of composition, viscosity and structure.
- No air incorporation during the continuous production, thus oil oxidation is prevented.
- The continuous system ensures an optimal swelling process of the starch phase. The heating and cooling temperatures can easily be controlled and the holding time in the holding cell is optimal and can be adjusted, if necessary. This results in optimal and constant viscosity and structure of the heated and cooled starch phase using a minimum of raw materials.
- Secures pasteurization of the starch phase.
- The starch is gently mixed into the mayonnaise at low shear in a short time. This results in limited breakdown of the starch particles and hereby ensures a homogeneous and stable structure of the final product. In addition, minimum mechanical heat is incorporated into the product, thus a low outlet temperature of 18 to 22°C is achieved.
- The GS Logic control system is designed to control, record and document important parameters regarding the process. For every recipe the GS Logic helps to create a consistent process environment to ensure that the product is manufactured in the same way every time.
- The closed inline process ensures an optimal hygienic level, and addition of preservatives can hereby be prevented.
- The GS continuous fine food line has shown that the use of the following raw materials can be reduced to a minimum: starch, yolk and preservatives, which results in a significant reduction in raw material costs.
- Limited product waste during start-up procedure.

ABOUT SPX

Based in Charlotte, North Carolina, SPX Corporation (NYSE: SPW) is a global Fortune 500 multi-industry manufacturing leader
For more information, please visit www.spx.com.

SPX FLOW TECHNOLOGY COPENHAGEN A/S

Oestmarken 7
DK-2860 Soeborg
Denmark
P: +45 7027 8222
gs.dk.sales@spx.com

SPX FLOW TECHNOLOGY HANSE GMBH

Bernsteindreherweg 7
D-23556 Lübeck
Germany
P: +49 451 3709 0
gs.de.sales@spx.com