

# Real-time At-line Measurement of Coagulating Milk Firmness to Optimize Milk Solids Retention Rate using CoaguSens™

Measure real-time firmness kinetics of coagulating milk with CoaguSens™

Cut at the optimal coagulum firmness and get more cheese from your vats

Trigger cutting automatically when optimal firmness is reached



Cheese making, milk coagulum firmness, vat yield optimization, process control

## WHY IS VAT YIELD IMPORTANT?

Cheese is obtained by coagulating milk with rennet and separating the milk gel into solid curds and liquid whey. The milk coagulum is cut into small cubes to increase curds surface/volume ratio and allow whey expelling from curds, a phenomenon called syneresis.

Coagulum firmness when being cut greatly affects milk Solids Retention Rate, which is the proportion of solids (everything but water) that goes from milk to cheese curds.

The Solids Retention Rate, specifically measures the coagulation step performance and the relevance of the chosen firmness at cut, contrary to the overall cheese yield that is affected by the process steps that follow coagulum cut and by cheese moisture. The Solids Retention Rate may also be called “vat yield” or “coagulation yield”. It represents the vat step efficiency to convert milk into cheese curds and is easily calculated from Milk Solids and Whey solids.

Solids that don't turn into cheese end-up as whey solids loss. Even though they may be recovered by various processes and turned into whey ingredients, it is in most cases more profitable to retain solids into cheese.

For a given milk composition there exists an optimal cutting firmness to reach the highest vat yield. Cutting the gel too soft leads to lower vat yield through increased whey fat loss, whereas cutting too firm results in too high curds moisture content and difficult crumbly curds cutting. Suboptimal cutting



CoaguSens™: automation instrument for at-line monitoring of coagulation processes.

firmness also alters the ripening process and final product quality.

Most cheese makers agree that better profit is made by turning milk solids into cheese versus reprocessing whey solids. Whey ingredients are lower value and require extra energy, equipment and staff. Higher vat yield makes more cheese from same milk volume. Milk production being responsible for over 90% of

cheese making carbon footprint, maximizing vat productivity directly contributes reducing the industrial environmental impact.

Presently, in cheese plants, milk gel is cut either at a fixed time, at a calculated time from measured set time and/or according to cheesemakers' subjective evaluation of gel texture and appearance. None of these techniques is perfectly accurate nor sensitive enough to firmness variation. This may lead to considerable fluctuation in vat yield, all the more that many factors affect the gel strength, such as seasonal milk composition changes and complex standardization that uses native milk along with various processed dairy ingredients. There is a clear need for objective, quantitative, at-line and real-time milk coagulum firmness measurement. This would deliver effective optimization of the coagulation step and yield, allow automatic cutting and reduce curd quality variations.

In this purpose, Rheolution Inc. developed CoaguSens™, the first mechanical testing instrument that allows:

- quantitative measurement of milk coagulum absolute firmness during the coagulation
- near vat real time monitoring of milk coagulation kinetics
- automatic cut triggering when target firmness is reached

This application note shares in-plant results demonstrating the capacity of CoaguSens™ to improve vat yield. Tests were conducted on Cheddar batches in a medium-size North-American cheese plant.

### COAGUSENS™ : HOW DOES IT WORK?

CoaguSens™ measures in real time the evolution of a milk sample firmness during its coagulation. A 200 mL renneted milk sample is taken from the vat and 2.7 mL is pipetted into a measurement cup (sample holder) that is placed in CoaguSens™ thermal chamber, regulated at the exact vat temperature. CoaguSens™ gets the actual vat temperature in real-time reading from the production automate. Thus, CoaguSens™ exactly mimics the full-size coagulation happening in the vat, without being in the vat.

CoaguSens™ measurements are non-destructive. The micro-vibrations applied by CoaguSens™ to the coagulating milk sample have only a few micrometers amplitude. This allows multiple measurements and to plot firmness kinetics over time. The patented technology behind this instrument is based on vibrations (mechanical) and is fundamentally different from hotwire (thermal) and light scattering technologies (optical).

CoaguSens™ makes direct measurements of the absolute firmness in pascal units (Pa) as opposed to the two other technologies that make indirect measurements of set time (not firmness) that is extrapolated to a theoretical recommended cut time.

Displaying in real-time the evolution of the coagulum absolute firmness is more relevant, more useful and more accurate. It mimics sensorial sensitivity of experienced cheese makers, but in way 27 times more precise.

CoaguSens™ offers the following specifications:

- Firmness (Elasticity) range: 25 Pa to 10,000 Pa (± 0.1 Pa)
- Thermal chamber: 20 to 50°C (±0.5°C) 68-122°F (±0.5°F)

- Interval between measurements : 1 second to 120 minutes
- Test duration: from 10 seconds to 1200 hours
- User interface: color touchscreen and CoaguTouch™ software
- Ingress Protection: IP65 (stainless steel 304, brushed #4)
- Communication protocol: Modbus TCP/IP, FTP
- Communication ports: USB 2.0 (2 X), Ethernet

comes with CoaguTouch™: a modular, user-friendly touchscreen-based user interface and software designed for test settings, data display and export. It is compatible with existing PLC-based control systems for automatic process control. CoaguTouch™ was optimized with cheese-makers to provide user-oriented tools to manage, display analyse, store and transfer data.

CoaguTouch™ may be used in two modes: 1) the automatic mode directly triggers curds cutting via existing industrial automates; 2) the manual mode lets cheese makers actuate cutting. CoaguSens™ then acts as an advisor and warns operators when it is time to cut. They would check curds texture and validate or delay cutting.

With time, CoaguSens™ becomes the ultimate cheese maker tool to control firmness at cut, meaning ultimate control on the coagulation step performance.



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### IN-PLANT VAT YIELD OPTIMIZATION WITH COAGUSENS™

#### Objectives:

1. To use CoaguSens™ to measure and plot coagulum firmness in real-time, close to vats.
2. To increase Cheddar batches Solids Retention Rate (vat yield) by determining the optimal coagulum cutting firmness.

The vat Solids Retention Rate was calculated from vat Milk Solids and vat Whey Solids (whey sampled after cut and rest time), both measured with a modern infra-red milk analyser.

$$\text{Solids Retention Rate (\%)} = \frac{\text{Milk Solids Weight} - \text{Whey Solids Weight}}{\text{Milk Solids Weight}}$$

Solids Retention Rate is a much better coagulation performance indicator than overall cheese yield that is influenced by cheese moisture and all the processes that follow coagulation.

The in-plant study took place in a North-American cheese factory using a highly enriched milk (4.2% protein, 14.5% solids) and unfolded in 3 typical phases:

## Learning

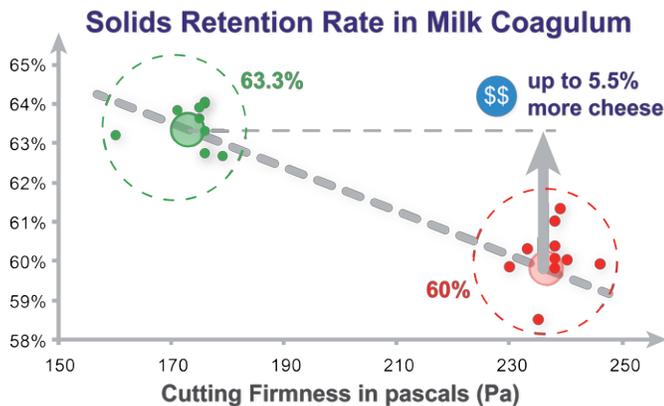
Coagulum firmness at cut was measured with CoaguSens™ for 40 batches (vats), cutting time being decided by the cheese maker, following his manual coagulum palpation technique.

## Stabilization

The average cutting firmness of the 40 learning phase batches was calculated (235 Pa) and used as the target cutting firmness for the 40 following batches. This move stabilized the coagulum cutting step. Vat yield averaged 60%.

## Optimization

Phase 1 gave clues that cutting softer increased Solids Retention Rate. So, cutting firmness target was moved from 235 to 170 Pa. As a consequence, Solids Retention Rate average moved from 60 to 63.3%.



16,000 Kg milk vats delivered 2,324 Kg of cheese at 60% Solids Retention Rate and 2,452 Kg at 63.3%, so 128 Kg more cheese per vat at 39% moisture content.

## A 5.5% vat productivity improvement was achieved

As in this particular plant, most cheese plants have processes to recover whey solids. However, it proves more profitable to turn milk directly into cheese than into lower value reprocessed whey ingredients.

## ECONOMICS & RETURN ON INVESTMENT

By delivering the absolute coagulum firmness in real-time to the cheese maker, CoaguSens™ uniquely allows perfect at-line control of the cutting step and swift optimization of vat yield.

Increasing vat productivity allows to produce more cheese from the same milk volume: man hours are less, energy consumption is less, need for extra vat investment may be delayed, customer spike orders may be addressed.

By displaying live coagulation kinetics, CoaguSens™ allows quick and early reaction to coagulation defects, human error or equipment failure (culture and rennet lower dosage or poor activity, milk defects, forgotten step or ingredient, equipment brake down etc.).

Whatever happens, CoaguSens™ tells you anytime what firmness the coagulum is at, so you can take the right decision and save your batch, yield and cheese quality. R.O.I. time depends on plant production volumes and varies from 3 to 10 months. One CoaguSens™ may be used for 2 to 3 vats depending on the average coagulation duration and vat overlap.

Staff to operate CoaguSens™ are cheese makers (or production operators) who routinely use CoaguSens™ to generate data and directly benefit from it. Production or process optimization managers use the exported data to build strategies to optimize the vat coagulation step. Starting a CoaguSens™ project requires focus but no extra staff. Rheolution offers full deployment support.

Milk price fluctuates, margins are tight, local and overseas competition is tough. No cheese making company can afford to miss out vat yield optimization. CoaguSens™ is the best tool to help you achieve this.

## WHAT TO REMEMBER

The cheese industry has long awaited a technology capable of mimicking milk coagulum manual palpation, while being more accurate and reliable. Hotwire and light-scattering technologies offered unsatisfactory results because they make only initial, indirect and unprecise prediction of a recommended cutting time. They also require to be installed inside vats.

CoaguSens™, from outside the vats, delivers real time measurement of absolute firmness in relevant pascal units (Pa) that compares to human finger feel. Coagulum firmness is measured with a 27 fold higher sensitivity than human fingertips, and plotted before cheese makers' eyes from renneting to cut and after. One firmness measurement may be done every second. As opposed to subjective palpation, CoaguSens™ firmness measurements are quantitative and may be saved and analysed with basic or advanced statistical tools. CoaguSens™ may work as the cheese maker's advisor or automatically trigger curds cutting.

These unique features allow perfect coagulation control and early reaction to any drifts. It also empowers cheesemakers, R&D and productivity improvement specialists to get the highest vat yield for each of their cheese recipe.

Even for highly standardized milk operations, coagulation kinetics do subtly vary. If curds are cut by the clock, suboptimal firmness at cut will periodically occur along with suboptimal yield.

In-plant tests revealed CoaguSens™ has the potential to greatly increase vat yield. Within weeks, Solids Retention Rate was raised from 60 to 63.3% and vat productivity by 5.5%.

**Enlighten the vat coagulation black box with CoaguSens™!**

**Contact Us Today to Start Improving your Coagulation Process**

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