

# Surface Modification to Improve Milk Cleanability of Stainless Steel Tubes

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## OBJECTIVES

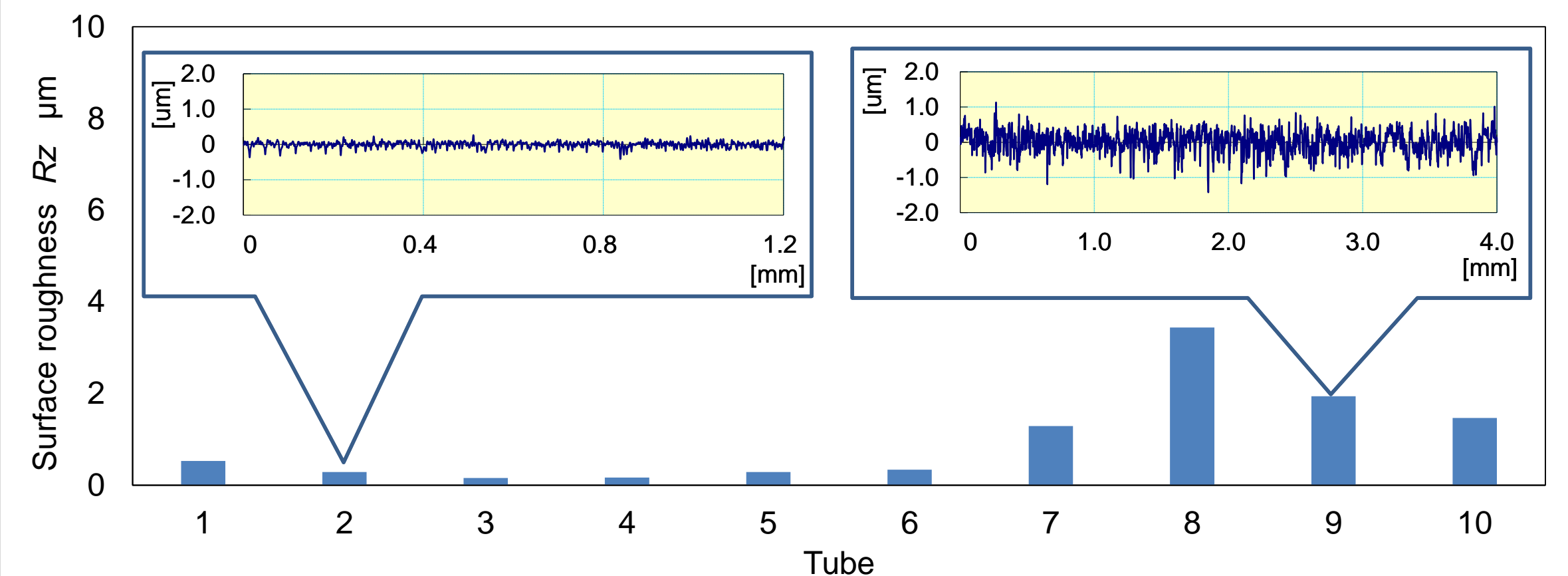
This project aims to eliminate biofilm deposition on the internal surfaces of dairy processing tubes, through the modification of internal surface characteristics utilizing the magnetic abrasive finishing procedure.

Eliminating biofilm deposition on internal surfaces of steel tubes can increase the quality of dairy and potentially reduce:

- cost of cleaning
- energy waste
- water waste



## FINISHED SURFACE ROUGHNESS



## MAGNETIC ABRASIVE FINISHING (MAF)

Magnetic particles and abrasive are mixed and introduced to a workpiece. A magnetic field generates the magnetic force of the particle on the abrasive that finishes the surface.

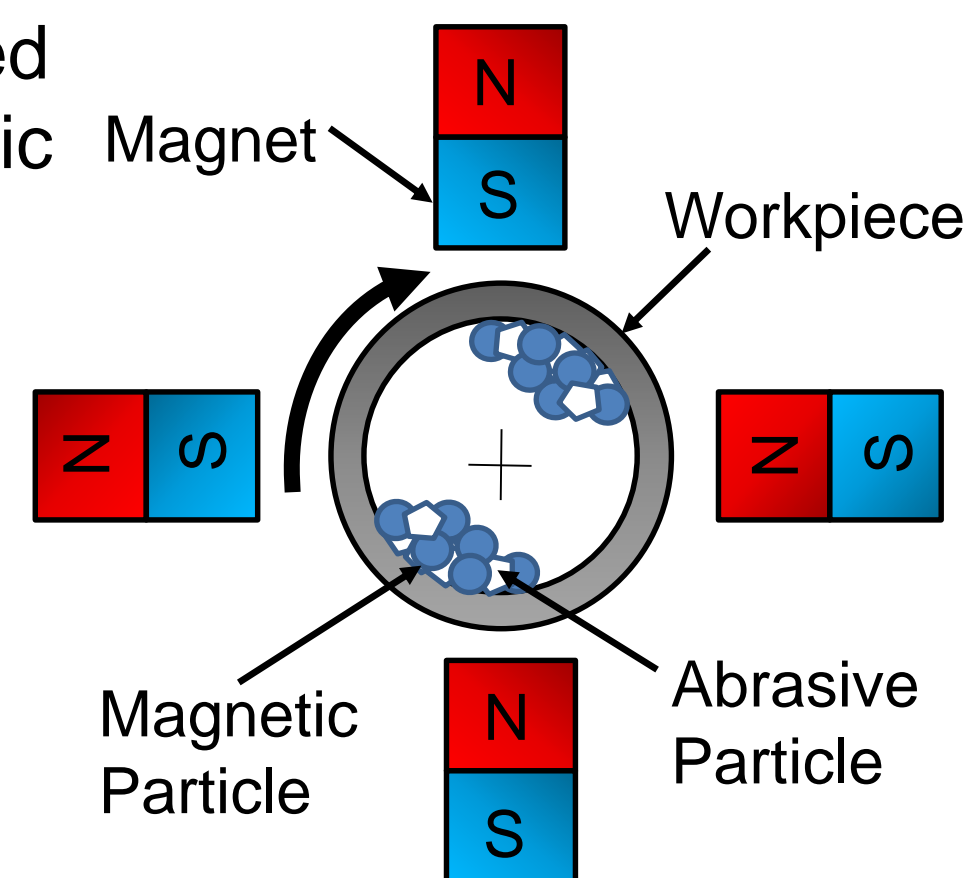
Force acting on magnetic particle

$$F = V\chi H\nabla H$$

$V$ : Volume of magnetic particle

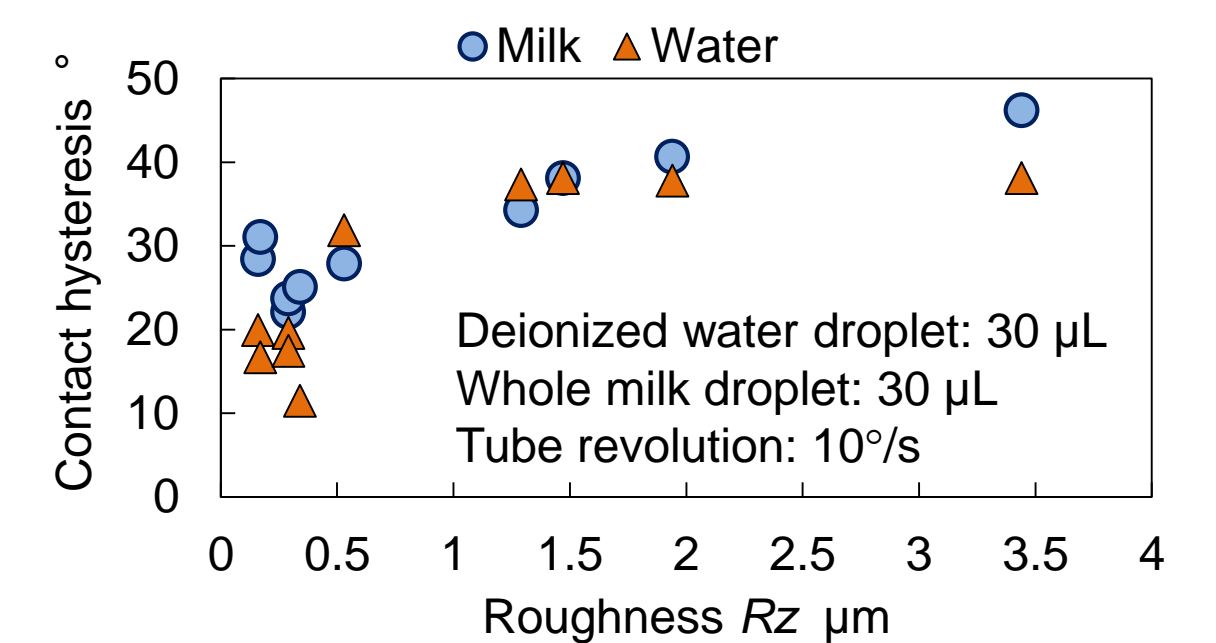
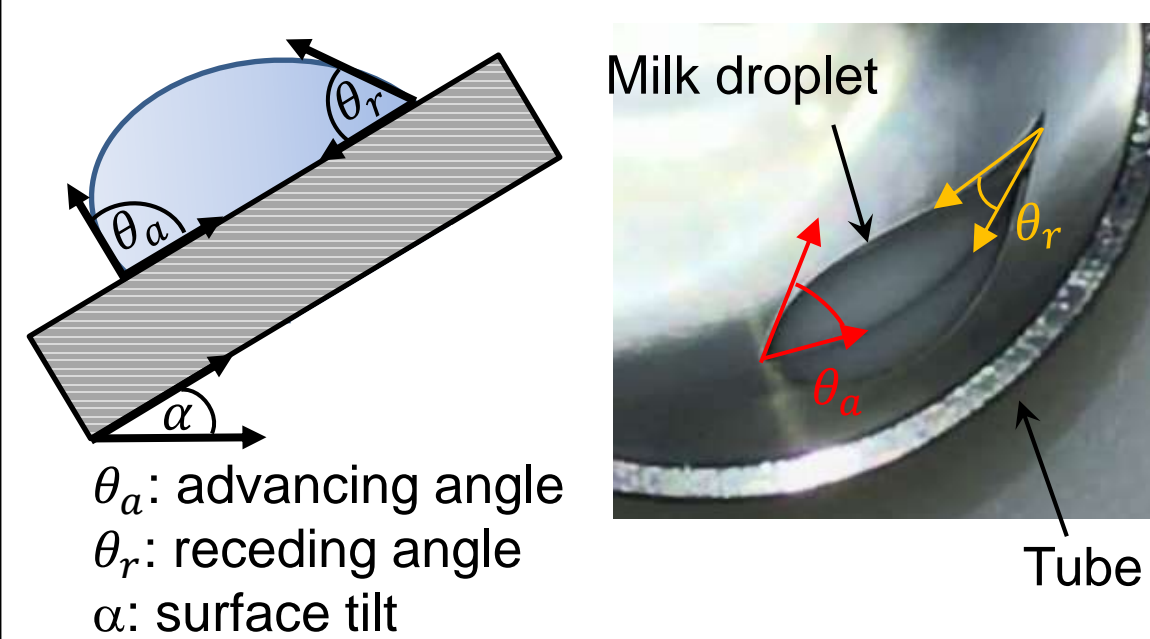
$\chi$ : Magnetic susceptibility

$H$ : Magnetic field intensity

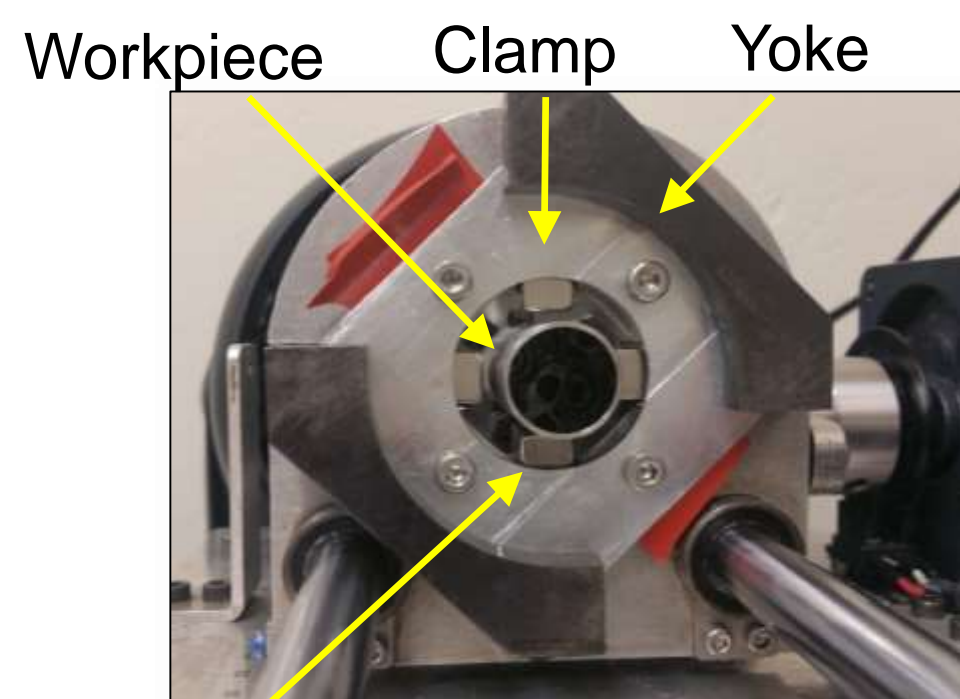


## DYNAMIC WETTABILITY

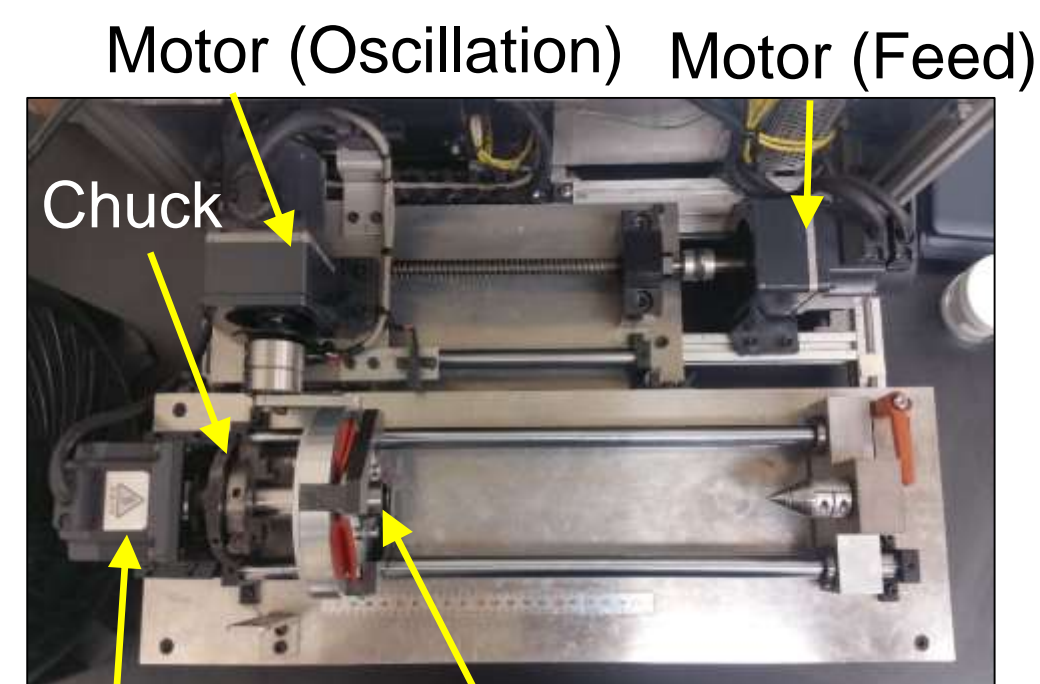
Wettability is the tendency of one fluid to adhere to a solid surface. Dynamic wettability is characterized by the difference in advancing and receding angles (contact hysteresis).



## MAF EXPERIMENTAL SETUP



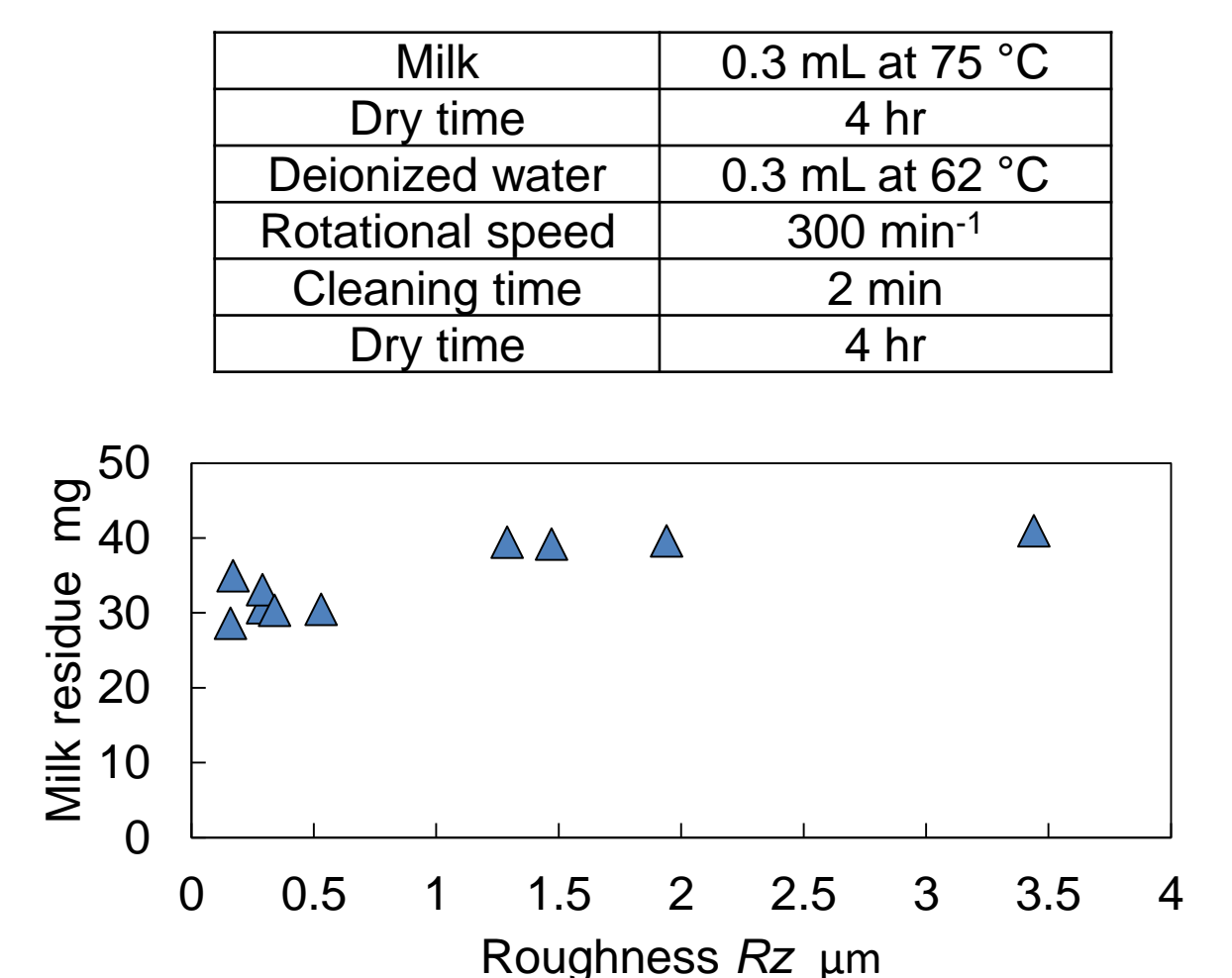
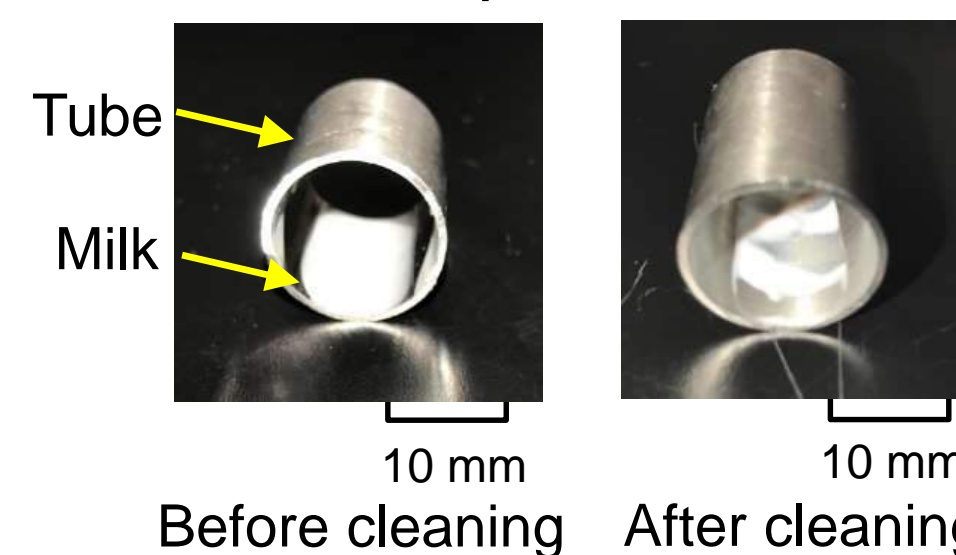
Nd-Fe-B Magnet  
(3/8×3/8×3/4 in)



Motor  
(Rotation)

## CLEANABILITY

Cleanability of the stainless steel tube, with respect to whole milk, is characterized by the mass of the residual deposits.



## EXPERIMENTAL CONDITIONS

No.	1	2	3	4	5	6	7	8	9	10
Workpiece	304 stainless steel tube (Ø20×Ø18×100 mm)									
Workpiece revolution	2000 min <sup>-1</sup>									
Abrasive	80 µm mean dia. magnetic abrasive (alumina abrasive < 10 µm)									
Magnetic particle	50 grit steel shot	177-595 µm iron particles	149-297 µm iron particles	25 grit steel shot	14 grit steel shot					
Magnet motion	Feed: 25 mm, Feed rate: 1 mm/s									
Magnet pass	4	8	4	8	4	8	4	8	4	8

## CONCLUSIONS

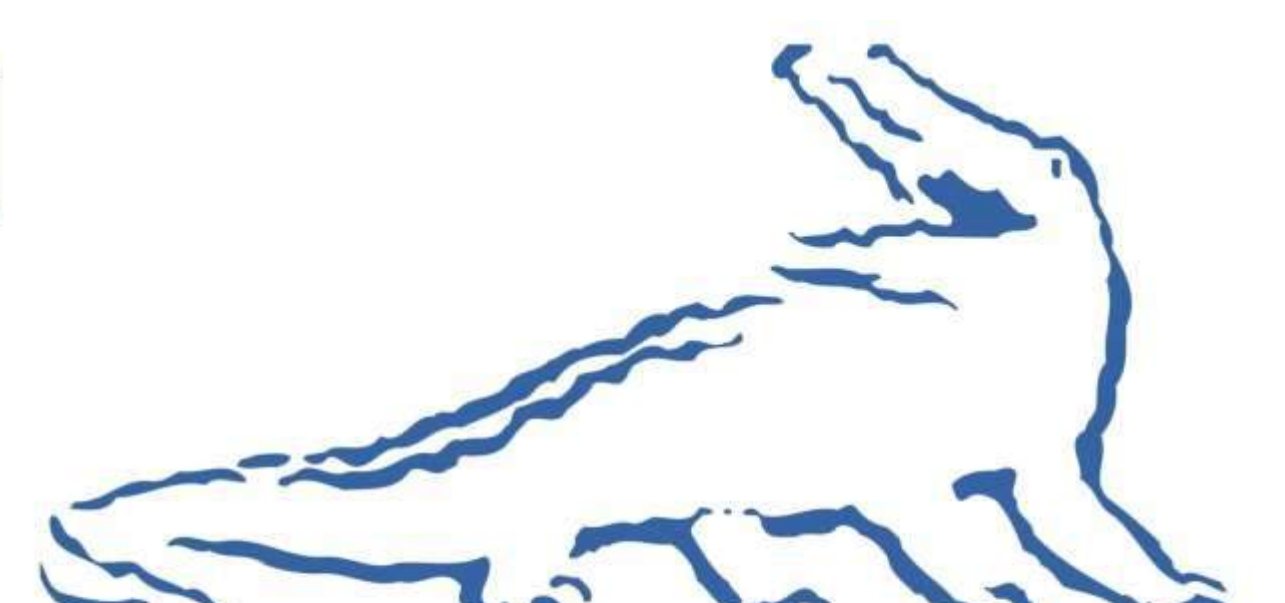
1. The contact hysteresis for whole milk on stainless steel tubes decreased with decreasing the surface roughness of the tubes.
2. The milk residue left on the surface after cleaning also decreased with decreasing the surface roughness of the tubes.
3. Altering the surface characteristics of the tubes improved the cleanability of the stainless steel tubes to whole milk.

## ACKNOWLEDGEMENT

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