ARTICLE 43-13
AUGUST 1960

THE RELATIVE CLEANABILITY OF DAIRY PROCESSING EQUIPMENT HAVING VARIOUS FINISHES[1]

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INTRODUCTION

THE RELATIVE CLEANABILITY of various finishes of stainless steel in dairy processing equipment under actual plant conditions has not been resolved. The finish has a significant effect on the intial cost of processing equipment, and until recently the effect of the finish on cleanability has not been evaluated. The relative cleanability of stainless steel with various finishes has been studied under laboratory conditions by Kaufmann[2] and Masurovsky,[3] and the cleanability of a farm bulk tank with various finishes has been studied by Kaufmann.[4]

Kaufmann[2, 4] found no significant difference in the relative cleanability of Type 302 stainless steel with 2B, 3, 4, and 7 finishes. Masurovsky[3] found no significant difference between finishes 4 and 7. In all three of these studies, soiling was done at low temperatures which may give results different from those obtained using high temperatures for soil deposition.

Two pieces of dairy processing equipment, a plate heat exchanger (HTST unit) and a pasteurizing vat with various finishes, were studied under commercial conditions as part of a study designed to answer the question of the relative cleanability of stainless steel finishes under processing conditions.

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[1]This project was supported in part by the American Iron and Steel Institute and the National Association of Dairy Equipment Manufacturers.

[2]Kaufmann, O. W., T. I. Hedrick, I. J. Pflug, C. G. Pheil, and R. A. Keppeler (1960). Relative cleanability of various stainless steel finishes after soiling with inoculated milk solids. Jour. Dairy Sci. 43: 28.

[3]Masurovsky, E. G., and W. K. Jordan (1958). Studies on the relative cleanability of milk contact surfaces. Jour. Dairy Sci., 41: 1842.

[4]Kaufmann, O. W., T. I. Hedrick, I. J. Pflug, C. G. Pheil, and R. A. Keppeler (1960). Relative cleanability of various finishes of stainless steel in a farm bulk tank. In press.

Reprinted from the QUARTERLY BULLETIN of the Michigan Agricultural Experiment Station, Michigan State University, East Lansing.
Vol. 43, No. 1, pages 122 to 128, August 1960

EXPERIMENTAL

Description of Equipment

The heating section and the cooling section of the HTST unit each contained 13 plates (6 sets plus 1); the regenerative section contained 29 plates. Three plates of each finish, 2B, 3, 4 and 7, were placed in the heating section in a randomizd manner to study the effect of location on cleanability since soil deposition in a HTST unit is not uniform.

A 150-gallon rectangular, spray-type pasteurizing vat with the lining specially fabricated from Type 302 stainless steel with Nos. 2B, 3, 4, and 7 finishes was used in these studies. The panels with the Nos. 2B and 4 finishes were 37 × 22.5 inches; the 3 and 7 were 42 × 22.5 inches. The bottom was made from stainless steel with No. 4 finish. All welds were polished equivalent to that of a No. 4 finish. The water and steam valves for heating or cooling were manually operated. The heating medium (a hot water spray) was circulated by a centrifugal pump at approximately 10 gallons per minute.

Soiling Procedures

The HTST plates were soiled in the normal heating of whole milk containing 3.5 per cent milk fat to a temperature of 165° F. The flow rate through the unit was approximately 7000 pounds per hour; operating time of the HTST unit varied from 4 to 6 hours per day.

A typical operating cycle for pasteurizing 140 gallons of whole milk at 148° F. for 30 minutes was used to soil the pasteurizing vat. The heating system was adjusted so that the temperature of each heating surface of the vat was the same, since it was assumed that soil deposition on a heating surface would be related to the heat transfer rate. Following pasteurization, the milk was cooled to a temperature of 136-140° F. and then pumped from the vat. When the pasteurizing vat was empty, cold tap water was fed into the jacket to cool the unit.

Soil deposition on the sides of the vat was variable. It appeared that the rectangular shape of the vat and the location of the agitator were responsible for the uneven soil deposition. A dramatic demonstration of the variation in soiling and the location of the soil was obtained when chocolate milk was pasteurized in the vat instead of whole milk.

Cleaning Procedures

The HTST unit was cleaned using a CIP procedure. At the end of the pasteurization operation, the system was flushed with cold water until the water draining from the unit was clear. With the press open slightly, five pints of organic acid cleaner in 70 gallons of water were recirculated at 175° F. for 30 minutes. A slurry containing 5 pounds of an alkaline detergent was added directly to the acid solution and recirculation continued at 175° F. for another 30 minutes. The detergent solution was removed by rinsing the system with water at 162° F. for 15 minutes. To minimize air contamination, the system was drained at the lowest point. The plates were bacteriologically tested before the unit was sanitized with a chlorine solution.

The pasteurizing vat was cleaned using a modified CIP procedure. A special cleaning device was constructed consisting of four tubes arranged so that one tube was parallel to each side of the tank; the horizontal distance from a tube to the side of the tank was ½ inch. The tubes were 30½ inches long with 1/16-inch holes drilled 1/4-inch O. C. The rinse or washing solution was pumped into an inner tube with holes located 180° from the holes in the outer tube; this gave a uniform distribution along the whole length of the tube. The tubes were rotated so that the angle between the spray streams and the surface of the vat was 73°. The liquid flow rate was 20 gpm for 119 lineal inches of vat.

The pasteurizing vat was cleaned immediately after use. To clean the vat, the washing device was placed in position and 10 gallons of water at 125° F. were sprayed on the soiled walls. This rinse was followed by recirculating a cleaning solution at 165° F. containing a non-chlorinated non-foaming alkaline detergent (1 oz. per gal. of water) for 15 minutes. Ten gallons of water at 125° F. were used as a post-wash rinse. The surfaces were bacteriologically tested before sanitization.

The water used in the cleaning studies had a hardness of approximately 200 p.p.m.

Testing Procedures

The plates in the HTST unit were evaluated bacteriologically using a modified standard Swab Test.[5] An area of 80 square inches was examined instead of the standard 40 square inches to obtain a more accurate sampling because of the low total bacterial count. A special

large swab approximately 3/4-inch in diameter was used to swab the greater portion of the area between adjacent peaks on the corrugated plate; the actual area of each valley was approximately 5.75 square inches.

To randomize the test areas, five corrugations were selected near the top of the plate; four were taken from the middle section; and five were taken from the lower section of the plate. Each corrugation was tested by passing a moistened swab along the entire length of the valley three times while rotating the swab stick. After swabbing seven corrugations, the swab was whip-rinsed in 12 ml. of sterile phosphate buffer.

Immediately after testing, 4 ml. volumes of the swab solution were plated directly using plate-count agar. All plating was done in duplicate; the plates were counted after incubation for 48 hours at 95° F. The total number of bacteria removed from each plate was calculated, and the results of these tests are shown in Table 1.

The standard Swab Test,[5] utilizing a 40-square inch test surface, was used to determine the bacterial cleanability of the pasteurizing vat. Three different 40-square inch areas on each finish were tested. Duplicate 4-ml and 1-ml plates were poured; they were counted after 48 hours incubation at 95° F.

RESULTS AND DISCUSSION

The bacteriological results on the HTST unit obtained with the swab test are given in Table 1. These values represent the actual counts obtained from an 80-square inch area on each of three different plates having the same finish. An analysis of variance indicates no significant difference at the 5 per cent level in the bacteriological cleanability of the Nos. 2B, 3, 4, and 7 finishes.

Preliminary evidence indicated that soil build-up on the heater section increases from the milk inlet to the outlet port. However, an analysis of variance indicated no significant difference in bacterial counts among the various finishes regardless of location.

Compliance with the maximum recommended standard[5] of 12.5 organisms per square inch was observed 100 percent of the time, notwithstanding the fact that sanitization was omitted. Lower levels of bacterial contamination undoubtedly would have been observed if the HTST unit had been sanitized with chlorine prior to testing.

[5]American Public Health Association (1953). Standard Methods for Examination of Dairy Products. 10th ed.

TABLE 1—Bacteria counts on plates having No. 2B, 3, 4 and 7 finish in a HTST unit prior to sanitization

Trial No.	Number per 80 square inches(a)			
	No. 2B	No. 3	No. 4	No. 7
1	12	15	8	8
	24	14	12	14
	14	8	18	14
2	6	18	18	24
	33	6	27	3
	15	3	23	9
3	186	363	3	6
	14	90	3	2
	36	42	5	2
4	105	6	5	2
	6	8	12	8
	6	...	6	6
5	3	36	33	21
	20	6	5	23
	24	...	5	15
6	18	6	6	3
	9	2	9	2
	5	...	21	8
7	18	18	11	12
	18	8	12	14
	30	...	18	45
8	9	6	75	11
	3	9	9	9
	3	...	5	3
9	2	11	6	9
	9	3	6	6
	2	...	12	3
10	27	3	23	6
	6	8	32	50
	23	...	120	14
11	45	0	111	0
	3	2	69	5
	0	...	3	0
12	2	17	30	6
	15	6	5	8
	11	...	12	8

TABLE 1—Concluded

Trial No.	Number per 80 square inches(a)			
	No. 2B	No. 3	No. 4	No. 7
13	3	2	3	2
	0	270	3	3
	0	...	8	0
14	110	144	135	12
	0	0	3	3
	2	...	8	0
15	3	3	3	11
	2	5	5	3
	2	...	3	3
16	0	2	2	8
	3	3	15	2
	0	...	2	0

(a) Average of duplicate plates (Suggested maximum standard is 1000/80 square inches).

The average bacteriological results obtained on the vat using the Swab Test are given in Table 2. Visual inspection of the soil on the vat immediately after emptying indicated an uneven deposition of soil on the walls of the vat which, in turn, makes comparison of cleanability difficult. Since the cleaning procedure employed was sufficient to

TABLE 2—Bacteria counts on a pasteurizing vat after detergent washing

Trial No.	Number per 40 square inches(a)			
	No. 2B	No. 3	No. 4	No. 7
1	30	63	27	52
2	25	31	20	45
3	22	27	39	19
4	15	10	5	8
5	10	8	5	16
6	10	4	10	10
7	5	19	8	4
8	5	5	4	28
9	24	7	3	3
10	28	53	12	15
Gr. av....	17	24	13	20

(a) These values represent the average of three replications.

remove the soil on the surface having the greatest accumulation, it was possible to compare the surfaces notwithstanding this variation. An analysis of variance indicates no significant difference at the 5 per cent level in bacteriological cleanability between the 2B, 3, 4, and 7 finishes using the cleaning procedure described.

It is interesting to note that 100 percent compliance with the recommended standard[5] was observed after rinsing and washing, regardless of finish; the uneven soil deposition apparently did not influence the final bacteriological results.

SUMMARY AND CONCLUSION

The bacteriological cleanability of Type 302 stainless steel with finishes No. 2B, 3, 4, and 7 was tested under commercial processing conditions in a HTST unit and in a pasteurizing vat; the HTST unit was cleaned using a CIP cleaning procedure; the pasteurizing vat was cleaned using a modified CIP procedure. The results showed no significant difference in the bacterial counts at the 5 percent level among the four finishes.

Since there was no significant difference in the bacterial counts of the four finishes, it must be concluded that there is no difference in the relative cleanability of these four finishes and that any of these finishes should be satisfactory for dairy processing equipment from a sanitation standpoint. Therefore, selection of a Type 302 stainless steel finish (2B, 3, 4, and 7) to be used under conditions comparable to those existing in these tests will have to be based on criteria other than bacteriological cleanability.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the assistance of Dr. W. D. Baten, Michigan State Agricultural Experiment Station, in the statistical aspects of this work.