Trends in Dishwashing Appliances: The Development of the Dishwash Market

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ABSTRACT

A comparison is made between types of dishwashing machines in the U.S. and in Europe. The trends to designs that will use reduced amounts of energy are also discussed.

The market for dishwashing machines has, in the last decade, become among the fastest growing markets for household appliances. The worldwide annual production, which amounted to 700,000 units in the early 1960s, predominantly in the U.S., increased to over 5.5 million units in 1975. Roughly one third of these are now produced in Europe. In the U.S., at this moment, 40% of the families own a dishwasher. In Europe this is now 10% (the introduction was 10 years behind that in the U.S.) but growing at a rate of 15% per annum. At such a rate ownership will double every 5 years.

The dishwashers in Europe are not evenly distributed. Countries like Sweden, Switzerland, Germany, and France are well above the average of 10% ownership; Italy is on the average, possibly due to the late introduction of color TV, but at present lagging behind in growth; Spain, Portugal, Greece, and the U.K. are definitely below the average. In the U.S. four and in Europe eight manufacturers given in Table I, account for 75% of the sales.

The major European manufacturers are concentrated in three countries, and two thirds of all European machines can be found in those countries. They are, however, oriented internationally to different degrees. Some firms export over 60% of their production to other countries, some sell over 90% in the home country. The result is that the different European countries not only have different customs in foods and substrate (the load), but also each country has its own particular mix of machine brands and models.

TECHNICAL DEVELOPMENTS

In this paper we will discuss general trends only, although both in the U.S. and in Europe machines can be found which do not conform to the trends. A comprehensive overview, however, is outside the scope of this paper. The technical development has been in turmoil, but fortunately a number of design features now have become similar. The number of place settings has settled on 10-12; the top-loaders have retreated in favor of the front-loaders; the rotating baskets have disappeared, and the racks have become square and stationary; and the fantastic array of spray systems including impellors, spray arms (sometimes with smaller ones fitted onto them), spraying drums, disks, nozzle heads, etc., all rotating merrily around, has come down to spray arms beneath each rack (in Europe and the U.S.) or beneath the under rack with a central turret to supply water to the upper rack (U.S.).

Between the U.S. and European machines some basic differences exist caused by the quality of the water available for the wash. In the U.S. ample hot and predominantly soft water is available in the kitchen; in Europe the wash has to be done with cold water, which is sometimes very hard and often contains considerable quantities of dissolved materials.

To obtain a satisfactory result under those circumstances the European machines became different from their U.S. counterparts in the following respects. Large capacity heaters (2500 W average) provide the heating power necessary to reach the desired temperature within a reasonable period of time. Built-in water softeners (optional a few years ago but presently a standard feature on each new machine) soften the water to the desired degree. Automatic rinse aid dispensers (in the U.S. only on the luxury models) have become standard equipment in Europe. It enables the housewife to obtain a good result on glassware even with a high solid content of water because the formation of drop-

TABLE I

Major Dishwashing Machine Manufacturers

U.S.	Europe	Home country
General Electric (GE and Hotpoint)	AEG	Germany
	Bosch	Germany
Design and manufacturing (Kenmore, Sears Roebuck)	Eurogeräte (Philips-Bauknecht)	Germany
	Miele	Germany
Hobart (Kitchen Aid)	Candy	Italy
Whirlpool	Indesit	Italy
	Zanussi	Italy
	CFTH-HB (Thomson Brandt)	France

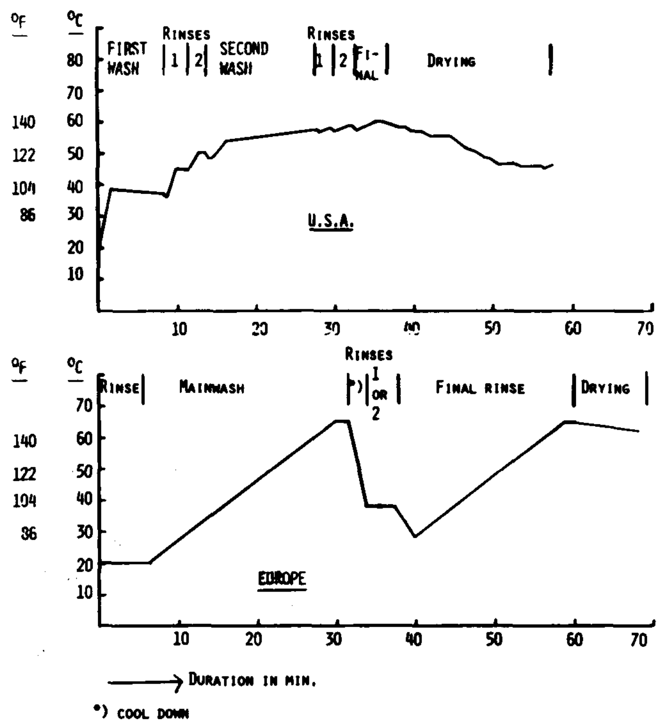

FIG. 1. Comparison of normal washing program.

TABLE II

Machine Characteristics

	U.S.	Europe
Wash conditions	No water softener	Built in water softener
	Hot water fill	Cold water fill
	One of two hot washes each followed by hot rinse	Cold prerinse Hot water Cold rinse Hot final rinse
	Rinse aid use not common	Rinse aid use the normal condition
Machine design	Circulation pump is also discharge pump	Separate pump for discharge and circulation
	Soft food disposer disintegrates food residues)	Only sieves
	Float type regulator of water level	Pressostat
	Mostly multilevel spray action Spraying under upper rack often provided from a central turret Tendency for the number of spray arms to be reduced in the cheaper models	Spray arms beneath each rack
	Linings: Porcelain on steel or plastic-coated steel	Stainless steel most common All-propylene also occurs

lets is prevented. The benefit of the rinse aid is well recognized by the European housewife because 90% of them use the product. The differences are especially reflected in the programs, representative examples of which are shown in Figure 1.

In the U.S. the machine is filled with hot water. Two subsequent wash cycles (wash-rinse-rinse) followed by a final rinse are quite normal. Rinse aid in the final rinse is used by not more than 25% of the housewives. Drying is achieved by switching on a small heater (750-1000 W) which is sometimes also used to boost the wash temperature. Drying may be accelerated by force circulation of air through a fan. In the figure, water with a temperature of 65 C was used, as recommended. The temperature in the first wash is nevertheless low, due to the fact that both machine and load are cold and absorb a considerable quantity of heat energy. Actual measurements that we carried out in the U.S. showed an average temperature, which was not as low as in the laboratory but not too far off (45 C). Such a wash temperature is not too harmful when a second wash follows at the correct temperature, but a number of people dose detergent only once, in the first wash. Performance in that case cannot be expected to be good.

The European machine takes in cold water through ion exchange softeners. This replaces Ca and to a somewhat lesser extent Mg with Na but leaves all the anions and soluble materials in the water. A regular regeneration of the resin is necessary. Although also a number of systems are still produced like this, the tendency is toward a common design which consists of a small size resin container that is regenerated automatically as part of the cycle from a tank containing salt for a number of regenerations. The program starts with a short cold prerinse. The purpose is to wash away loose soil and also to ensure that possible salt and hardness residues from the regeneration step are flushed out. One hot main wash follows. Double washes, although encouraged in some machines by the dispenser design, are not common practice in Europe. The hot wash with temperatures close together at an average of 65 C is followed by a cold rinse. To avoid too great a temperature shock the wash liquor often is first diluted with the cold water. The final rinse is heated again, and rinse aid is dispensed shortly before the end to avoid foam formation, which might cause uneven drainage. Drying is accelerated by switching on the heating coil at reduced capacity.

A summary of the differences between the U.S. and European machines is given in Table II.

FUTURE DEVELOPMENTS

A logical extrapolation for the European machines, which are already automatic in dispensing rinse aids and salt solutions from multiwash containers, would be to become fully automated, including the dispensing of a detergent from a reservoir. Although such a development is seen as a distinct possibility, it will not be the most imminent one.

The next phase will be the reduction of energy consumption. Dishwashers are relatively high consumers of energy. The rising costs of energy, the consumer associations' attention to energy consumption, and above all the pending regulations and legislation of European countries and American states, will make such a development necessary.

The official propositions range from energy labeling as KWh per wash or KWh per place setting to officially indicate targets for energy efficiency improvements as the 20-40% reduction, which the Federal Energy Administration considers possible. A comparison of the energy distribution over the cycle for the U.S. and European machines is shown in Table III. In Europe electricity is the energy source used to produce hot water. In the U.S. it is mostly

TABLE III

Energy Consumption

	U.S.		Europe	
	Electrical	Primary	Electrical	Primary
Pump	0.3	1.0	0.4	1.3
Heater	0.15	0.5	1.7	5.5
Drying	0.3	1.0	0.2	0.7
Hot water	—	4.2	—	—
Total	—	6.7	—	7.5

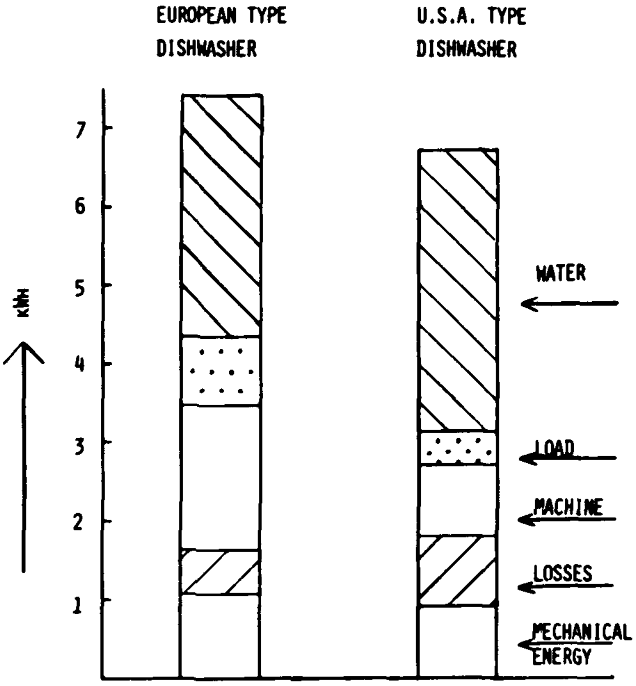

FIG. 2. Distribution of primary energy consumption.

mineral fuel. Taking into account the 30% efficiency with which mineral fuel is converted into electricity and the 60% efficiency of the nonelectrical water heater, the comparison expressed in KWh of primary energy comes out in favor of the U.S. system. The distribution of this energy in terms of the machine and its load is given in Figure 2.

The pump provides the mechanical action, but a certain percentage of the energy input is converted to heat instead of kinetic energy. The losses are partly radiation losses and partly evaporation losses. For a 60 C program they are roughly as indicated but rise sharply at higher temperatures. Losses are somewhat higher for the U.S. because the machine is warm for a longer period. The heat energy put into the machine and the load is roughly twice as high in Europe due to the cool-down between main wash and rinse. Most of the energy in both cases goes into heating the water which is afterwards drained away.

POSSIBILITES FOR ENERGY SAVING

In theory, savings could be made by reduction of the water temperature, reduction of the water volume, and economizing on the drying step. The consequences for the U.S. and Europe are understandably different.

Reduced Water Temperature

A reduction of the wash temperature is not recommended. A temperature of 60 C is necessary to get a sufficient reactivity of the detergent chemicals and to loosen the adhesive bonds between soil and substrate. A reduction of the rinse temperatures in the U.S. should be tolerable. This, however, leads to a cooler machine in the washes and if electricity is used to heat up the system to the temperatures which are regular now, it can easily be calculated that in terms of primary energy the saving is negligible.

Reduced Water Volume

In the U.S. the easiest way would be to restrict the number of rinses. If a low carry-over value can be established (the percentage of liquor transported from one stage to the next), good results must be possible as in the European system. A reduction in carry-over can be established by machine design, by flushing the drain system between the stages, and by optimizing detergent products on lathering properties because a considerable amount of liquor is trapped in foam remaining behind after draining the machine. Elimination of two rinses would then save roughly 15% of the primary energy consumption.

For Europe the only possibility is to reduce the volume of the wash and rinse. It is a much more difficult task because, especially during the wash, the suction end of the pump must not run dry. Mechanical action is lost and air may be dispersed in the wash liquor. This route, therefore, will lead to a redesign of the machine, keeping the internal volume of the circulation system (pump, pipes, spray arms) to a minimum, redesigning the jets so that water is optimally directed to the load, redesigning the sump and bottom part of the machine to direct the liquid quickly to the pump. Machines designed according to these principles are starting to appear in Europe. The energy savings of such a system amounts to 20-25% in primary energy (both in Europe and in the U.S.).

For the detergent products this approach will have consequences. More attention will have to be given to lather depressing properties because the concentration of soil per liter increases, and the machine is more sensitive to liquid retention in the foam. Second, the changed balance between Ca^{++} delivered from the soil and from the water, the higher concentration of soil particles against a lower concentration of other materials dissolved in the tap water, will make it necessary to rethink our present ratio of components and the recommended dosages.

The Drying Step

The drying step offers the last possibility to save energy. In the U.S. this step consumes somewhat more energy than in Europe. The use of Ca^{++} rinse aid helps considerably in drying efficiency because it is much easier to evaporate a certain volume of liquid present as a thin film than as separate droplets.

In the U.S. a number of machines already have the option of switching off the heater during drying, using the heat stored in the load. Again, the use of a rinse aid would contribute considerably to the drying efficiency. In Europe most of the energy invested in the drying process goes into the water that is used to transfer from the heater to the load. A reduction of the water level must be possible even in machines which will lose mechanical efficiency, as long as the circulation is powerful enough to reach all articles. No consequences for the rinse aid formulation are foreseen in this case.

A different possibility for Europe would be to adopt the U.S. power drying system with hot air being blown over the articles. Even when the last rinse is left cold, good drying can be obtained in the same time as is customary for heating up 10 liters of water to 65 C and drying afterward for 10 min at roughly one third of the energy of the conventional system. Here, however, the changed drainage and evaporation at lower temperatures will make a reformulation of the rinse aid necessary.

The conclusion must be that the next phase in dishwashing machine development – energy saving – must be possible, but needs the concerted effort of both the machine and the detergent manufacturer.