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Does the energy labelling system for domestic tumble dryers serve its purpose?

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ABSTRACT

Tumble dryers sold on the market today are labelled according to their energy efficiency. This labelling system has primarily two purposes: to guide buyers to a product with low energy use, lower cost and lower environmental impact and to encourage producers to develop even more energy-efficient products. Tumble dryers are optimized for their maximum capacity, which is used as the standard load for determining the energy label. Three different tumble dryers have been tested with different drying loads. Results indicate that all the tested tumble dryers have significantly lower energy efficiency when drying small loads. In order to encourage the development of tumble dryers with high energy efficiency at drying loads used in ordinary households, the standards for the energy labelling system should be revised.

1. Introduction

Tumble dryers are more and more frequently used in ordinary households. They offer a fast and convenient way of drying textiles independent of weather conditions. However, artificial drying of textiles consume large amounts of energy, approximately 77 TWh (or 3.3% of the residential electricity consumption) was used in 2000 for drying of textiles in 22 IEA member countries (Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States) (International Energy Agency, 2003).

There has been developed a labelling system for tumble dryers according to their energy efficiency. The labelling system was introduced with the purpose to guide the consumer who can choose a product with high energy efficiency in order to lower the costs and environmental impact during use. It also has the purpose of encouraging the producers to develop even more energy-efficient products in order to be competitive on the market (Swedish Energy Agency, 2006). There has been a large increase in energy-efficient washing machines in Europe since the labelling system was introduced (Throne-Holst et al., 2007). In Europe white goods are marked with a letter according to its energy efficiency (Swedish Energy Agency, 2005). An A denotes a high energy efficiency while an F stands for a low energy efficiency.

Today, the standard drying load used in tumble dryers for determining the energy label (Swedish Standards Institute, 2001) is the maximum capacity of the dryer. The standard for the labelling system does not give any information regarding the energy efficiency when a smaller load is dried. The maximum capacity for tumble dryers has increased over the years. The producer's aim is often to increase the capacity of the dryer to 6, 7 and even 8 kg dry load as the maximum capacity often is used as a sales argument. According to Bengtsson (2010), the maximum capacity of both washing machines and tumble dryers is an important factor especially when there are several similar products available on the market. From a consumer point of view a product with large capacity stands for a well-designed product with high standard. However, Bengtsson also points out that a sales argument like this is something that most likely changes over a period of time.

Trends show that the washing loads in general are getting smaller (Henriksson, 2000). This can for instance be a result from the use of many varying fabrics and colours that should be washed separately. That more and more households are equipped with their own washing machine and tumble dryer, instead of using a common laundry room also reduces the size of the load. The total amount of laundry has however increased over the last decade (Gram-Hanssen, 2008; Henriksson, 2000; Lindén et al., 2006). No study has been found in the literature regarding the average size of the drying load used in households. For washing machines there is a German study by Berkholz et al. (2007) including 100 households concluding that the average washing load was 2.9 kg (dry load). In this study washing loads smaller than 2 kg (dry load) were found to be quite common in the most frequently used washing programs. According to an Australian study (Psiroukis, 2010), users believed

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Nomenclature

EEI	energy efficiency index [kWh/kg dry load]
M_{in}	moisture content of wet textiles [%]
M_{out}	moisture content of dried textiles [%]
m_t	mass of conditioned dry load of textiles [kg]
Q	measured energy use [kWh]
Q_{adj}	adjusted energy use due to remaining moisture in textiles [kWh]
T_f	temperature of the internal airflow between drum and fan [°C]
T_h	temperature of the internal airflow between heater and drum [°C]
T_{hx}	temperature of the internal airflow between heat exchanger and heater [°C]
T_{Hxi}	temperature of the inlet external airflow [°C]
T_{Hxo}	temperature of the outlet external airflow [°C]

the washing machine to be full when it was filled only to half its capacity. Shove (2003) presents that American households currently wash an average of 1.332 kg (dry load) of laundry a year, made up of 392 loads of 3.4 kg. This is nearly twice the volume washed in the UK where 274 washing cycles are run with an average 2 kg (dry load). The average load in the washing machine could be considered a maximum average load for the tumble dryer. Several items are not suitable for tumble drying and are therefore removed before inserting the load in the dryer. This means that a drying load of 1.5–2 kg (dry load) could be a frequently used load in households.

Several studies indicate that the tumble dryers' energy efficiency is smaller if the load is lower than the dryer capacity (Bassily and Colver, 2003a, 2003b, 2005; Conde, 1997; Yadav and Moon, 2008; Liu et al., 2008). As the maximum capacity of the tumble dryer has increased, the energy efficiency of the dryer indicated by the energy label increases for the maximum drying load (Bassily and Colver, 2003a, 2003b, 2005). As the drying loads in normal households tend to decrease, the ratio of the average drying load to the maximum capacity of the tumble dryer decreases. By decreasing such a ratio, the energy efficiency will decrease (Bassily and Colver, 2003a, 2003b, 2005). Accordingly, the energy labelling system is misleading. With this taken into consideration, there is first of all a need for a development of dryers with better performance at small drying loads. Secondly, the energy labelling system should be revised in order to encourage development in this direction.

At present a new ecodesign label for white goods is developed in EU. Ecodesign is used for designing products with as low environmental impact as possible. In the draft regarding the ecodesign label for washing machines, both the maximum capacity of the washing machine and a half load are used in the test standards (European Commission, 2010a). In the working document on the ecodesign and labelling of household tumble driers a half load and the maximum load of the dryer are suggested in order to define the energy label (European Commission, 2010b). In a report presented by ANEC, the European consumer voice in standardisation, an update of the test standards reflecting changes in consumer behaviour is suggested (ANEC, 2007). They state that some test standards are argued not to be representative for consumer usage of the products, in particular for washing machines. They also point out compliance problems regarding test of appliances, as this is still a matter of self-classification.

The aim of this paper is to analyse if the standard for the energy labelling of domestic tumble dryers serves its purpose, when factual consumer behaviour is considered. We will give a short introduction to the technique of tumble dryers and analyse the energy efficiency of three tumble dryers from different manufacturers for different loads. Finally, we will briefly discuss different ways to improve the energy efficiency for dryers at small drying loads and suggest improvements of the standard for the energy labelling of domestic tumble dryers.

2. Descriptions of the tumble dryers

Two condensing tumble dryer and one heat pump dryer have been tested in this study. In both dryers the drying air is recirculated in a more or less closed system. As shown in Fig. 1, the main components of a typical condensing tumble dryer found on the market today are: a rotating drum containing the wet textiles, two fans, a drying gas heat exchanger and an electric heater. The internal airflow transports the water vapour from the wet textiles in the drum to the heat exchanger where it condenses. The humid air is cooled in the heat exchanger using the external room airflow.

In the heat pump dryer the heat exchanger and the electric heater are replaced with an evaporator and a condenser of a heat pump cycle containing a circulating refrigerant. The humid air leaving the drum is cooled in the evaporator and thereafter heated in the condenser. This type of dryer uses significantly less energy than an ordinary dryer, however, the investment cost for this dryer is still high.

The ideal drying process in a tumble dryer can be described in three different stages, see Fig. 2, regarding the drying air: humidification (A–B), dehumidification (B–C) and heating (C–A). The drying air is humidified in the drum, where heat from the air is transferred to the wet textiles and water is transferred to the air. Ideally this occurs at constant enthalpy, if heat losses to the surroundings are neglected. The air leaves the drum saturated with water, a relative humidity of 100%. Thereafter the air is lead into the heat exchanger, where the water in the air is condensed. The air is then heated at a constant humidity ratio. The energy use for an ideal process in a condensing tumble dryer is 1840 kJ kg^{-1} dry load, where the energy supplied to the dryer is used for evaporating water and rotating the drum and fans.

In order to improve the energy efficiency of the dryer the aim should be to approach the ideal process with small heat losses. The

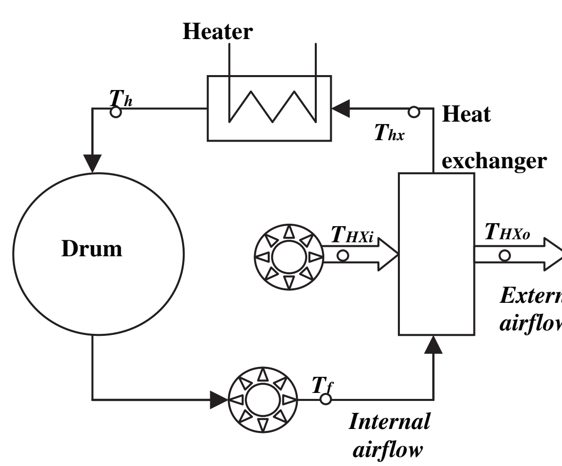

Fig. 1. Schematic figure of the components of a condensing tumble dryer. During the constant drying rate period, the temperature of the internal airflow leaving the heater, T_h, is 90–100 °C, after the drum the temperature has been reduced to 50–55 °C, T_f. The heat exchanger is cooled with room air at a temperature of 20 °C, T_{Hxi}, which leaves the dryer at 40–45 °C, T_{Hxo}. The air entering the heater typically has a temperature of 45–50 °C, T_{hx}.