

## EVALUATION OF POLYETHYLENE BASED INSULATION MATERIAL IN TEXTILE DYEING MACHINES

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**Abstract:** Energy efficiency efforts are getting more importance in accordance with the better understood of the sustainable development in all over the world. Accordingly improvements in the energy efficiency, reducing energy intensity both sectoral and macro-level are primary components of Turkish national energy policy. Textile sector has a significant share in the production and export industry of Turkey. A significant percentage of heat energy is being lost in the dyeing processes through wastewater, equipment surfaces, and exhaust gasses. These energy losses can be reduced via an efficient isolation of the machinery. The subject of this study is to evaluate the energy-saving efficiency of a highly cross-linked polyethylene foam insulation material in textile dyeing machines. Dyeing machines are heated to 130°C and cooled again during the process. 27% heat saving was achieved after 48 tons of dyed fabric in 20 days of trial period.

**Keywords:** textile finishing sector, energy saving, heat loss, isolation

### Introduction

Energy is one of the main factors of economic and social development and indispensable input of the production. Accordingly, energy demand is continuing to increase in all over the world due to the factors such as population growth, improving technology and trends for rising life qualities. Projection studies indicate that in case of the continuation of current energy policies, global energy demand will reach about 1.5 times of 2014 value in 2040 by 1.4% annual increase ratio (from 13.68 Mtoe to 19.64 Mtoe) (EUAŞ, 2014, IEA, 2016). On the other hand, the largest contribution of fossil fuels to the energy supply, corresponding climate change problem, the increase in the energy costs and the depletion risks of the fossil fuels make necessary the efficient use and saving of energy.

Energy efficiency is defined as the mitigation of the energy consumption per unit or product amount without leading to the decrease of the quality and the quantity of production, economic development and obstructing the social welfare (Url-1). It is a growing policy priority for the most of the countries around the world and widely presumed as the most cost-effective and readily available. That is addressing the energy supply security, the economic and social impacts of high energy prices, and concerns about climate change (Url-2). The policies on the energy efficiency are “required to be sensitively discussed because of its direct relation to the economic and social development objectives’ sustainability and its key role played in reducing the total greenhouse gas emissions”. Reducing energy intensity both sectoral and macro-level is significant and primary components of Turkish national energy policy. Turkey’s 2023 national strategic objectives and energy policies include providing energy supply safety, reducing the external dependency, the sustainability of the energy costs, protecting the environment and increasing the efficiency of the struggle against the climate change, those all fulfil the national strategic targets of Turkish energy policy (Url-1). Consequently, energy efficiency should be improved in all stages from energy production to the consumption at the end users. Through the energy efficiency studies, energy intensity that is energy consumption per national income of Turkey is aimed to be reduced (energy consumed per national income) as 20% until 2023 compared to 2011 (Official Gazette, 2012).

Textile sector has a significant share in the production and export industry of Turkey. The number of the enterprises and the employees correspond to about a quarter of the manufacturing sector whereas value added has 16% share as given in Table 1 (MoDev, 2014). Besides it has been mentioned as the 3<sup>rd</sup> most energy-intensive sector after iron-steel and cement industries in Turkey (Alkaya and Demirer 2014, Ozturk, 2005).

**Table 1:** The shares of textile and ready to wear sectors in Turkish production industry, % (MoDev, 2014)

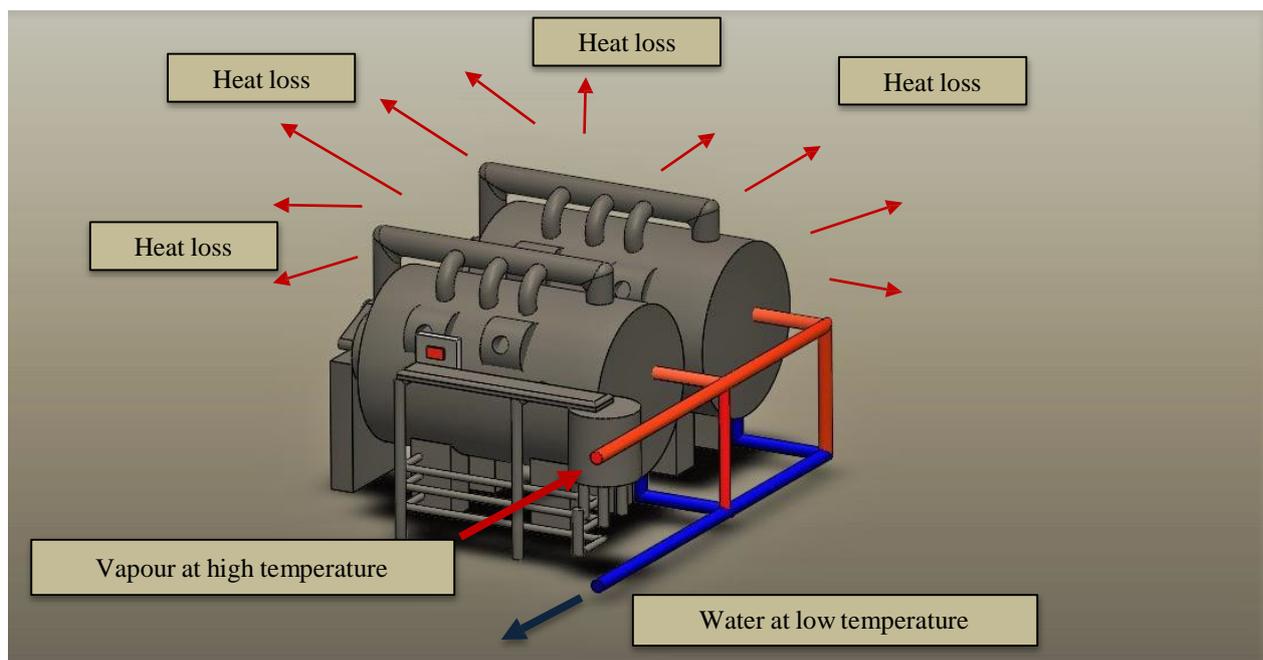
Number of enterprises	23,3
Number of employees	26,3
Production values	14,9
Value-added	15,5

Energy cost corresponds to 8-12% of the total production cost in the sector (Gümüşderelioglu, 2009, Koç University, 2012, Palamutçu, 2010). On the other hand, the most demanded energy type that is more than 80% of the total demand is the heat energy in the textile industry. Approximately 50% of this energy is lost through wastewater, the surface of the machines and exhaust gases those indicate the most energy saving potential (Moser and Schnitzer, 1985, Yamankaradeniz. et. al, 2007, Url-3). Besides, in a globalizing world, the increasingly difficult competitive conditions necessitate a reduction of the production costs.

The aim of this study is to evaluate the energy-saving efficiency of a highly cross-linked polyethylene (PE) foam insulation material used on the dyeing machines in a textile finishing sector. This is one of the initial studies on prevention of heat losses for dyeing machines including also cooling processes. In this study, the cost and the energy saving potential of glass wool and polyethylene based insulation materials are compared for reducing heat losses in dyeing machines.

### Materials and Methods

The finishing processes in the factory include dyeing with machines those are heated to 130°C and cooled again. The most of the energy cost comes from heating processes in textile finishing sector. Stainless steel made machines are used and during the whole process, significant heat is lost mainly at the surfaces. A typical dyeing machine is given in Figure 1.



**Figure 1.** Typical dyeing machine

In the dyeing processes corrosive chemicals are used with water. Therefore, the use of chemical resistant isolation materials is essential. Currently, 26% of heat saving is achievable with some of the machines those are isolated with silicone coated glass fiber and glass wool blended material in the factory. Due to no adhesive property, this material can only be applied via roping or snap fasteners to the machinery. Therefore, it cannot be applied to the small joints of the machines, on the surfaces where the shapes are changing, and recess ledges of the machines, where all cause the most energy losses. Furthermore, the insulation material is susceptible to water and especially to the chemicals used in the processes consequently, deformations began to occur at the end of the first year and it needed to be totally changed at the end of the second year. Therefore, more corrosive resistant isolation materials are needed to be used.

In this study highly cross-linked polyethylene foam material is used as an alternative to the silicone coated glass fiber and glass wool blended material for the isolation of dyeing machines. The material has adhesive property thus whole machine surfaces even recess ledges and small joints of the machines can be isolated. Applying is quite simple that it can be attached on the machines by steam or hot water and efficiently block the heat transmission. Due to the high thermal insulating property, heat and a great chemical resistance much energy saving and long lasting isolation are expected. Moreover, it can be cleaned easily.

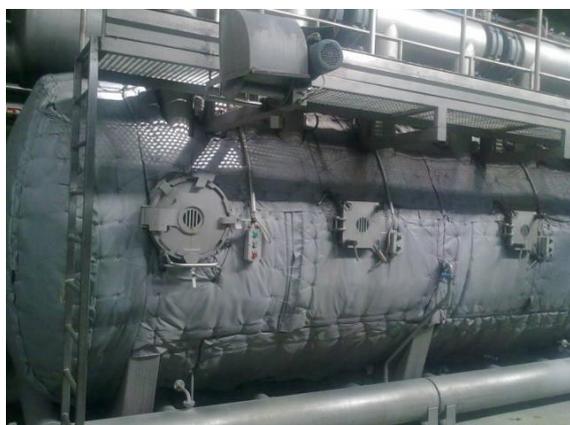
Three types of dyeing machines having same technical properties with 900 kg capacities were used in the trials. These are:

1. without isolation; as the reference case
2. isolated with silicone coated glass fiber and glass wool blended material
3. isolated with highly cross-linked PE foam material. (Fig.2-4).

The same process conditions were set for all the machines and the saved energy was compared to both insulation materials in order to determine the material that is more long lasting and can provide energy saving more. Energy saving was evaluated basing on the steam and cooling water consumption of the machines. Measurements were made 20 working days for all the shifts (3 shifts in a day). Cotton-polyester dyeing and cotton dyeing processes were tested. The outer surfaces of the dyeing machines and machinery temperatures were measured with thermal cameras to see the heat losses. The results are given in Fig. 5. hot surfaces indicate the places of the energy losses. The values have also been verified with the actual temperatures on the machines.



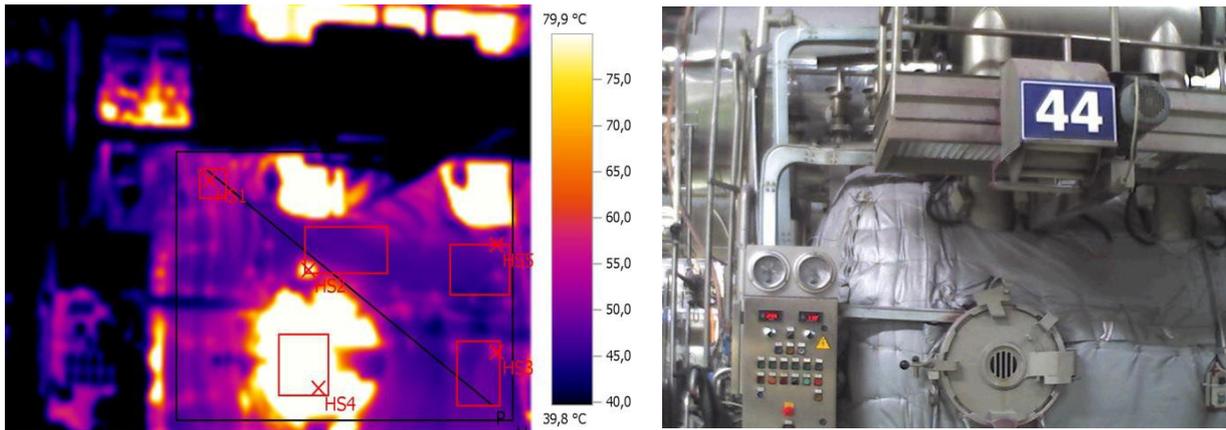
**Figure 2.** Dyeing machines without isolation



**Figure 3.** Dyeing machines isolated with silicone coated glass fiber and glass wool blended material



**Figure 4.** Dyeing machines isolated with highly cross-linked polyethylene foam manufactured insulation material

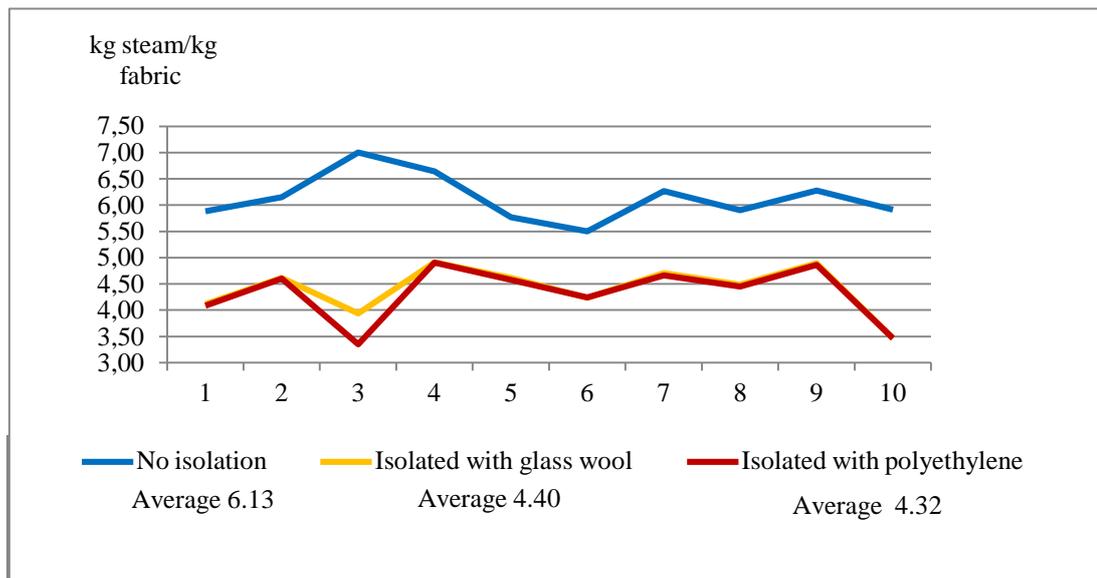


**Figure 5.** Thermal camera views of the machines

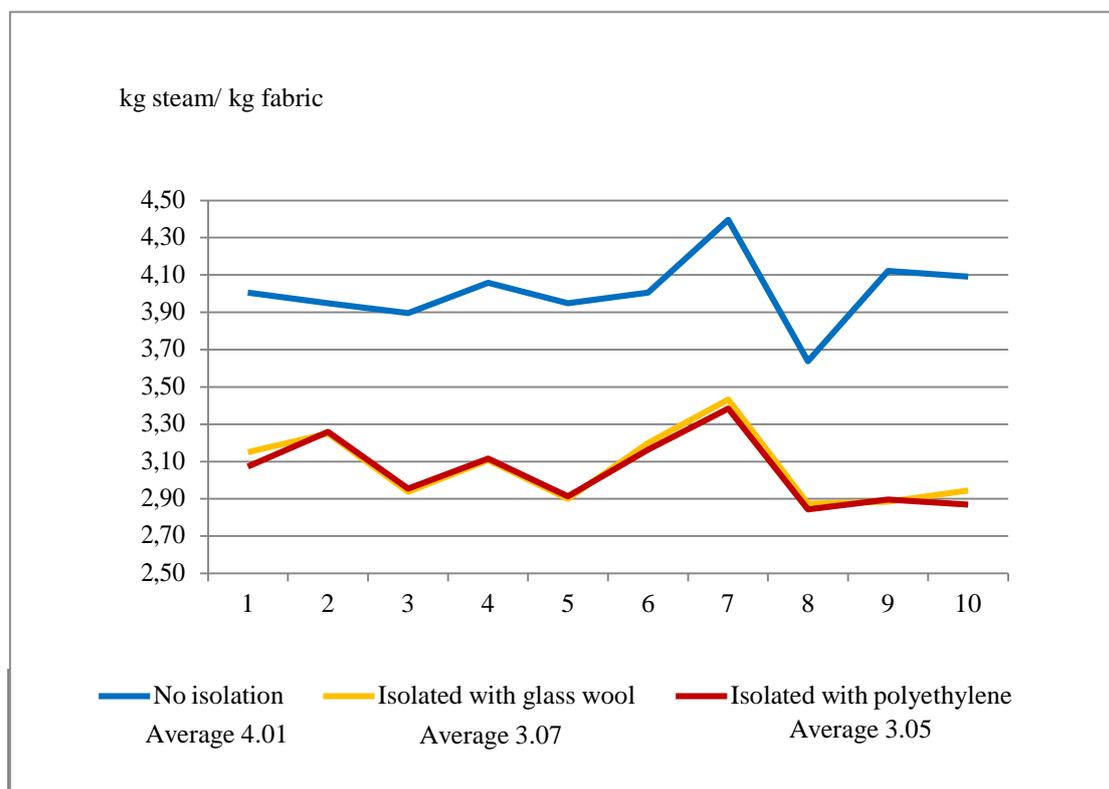
Due to the cooling times of the machines changes, process recipes are also checked if any adjustments are needed for the evaluation of the isolation material.

### Results and Discussion

At the end of the 20 working days, approximately 48 tons of fabric was dyed through 60 trials. The unit steam consumptions that is kg steam needed per kg fabric, were compared for the same garment dyeing processes in the tested machine types and the results are given with Figures 6-7.



**Figure 6.** Unit steam consumption in the cotton-polyester dyeing process



**Figure 7.** Unit steam consumption in the cotton dyeing process

The results indicate the energy saving with:

- the silicone coated glass fiber and glass wool blended material is: 25.76%,
- highly cross-linked polyethylene (PE) foam insulation material is: 26.6%

in the tested machines. The energy saving potential seems similar for both materials. 62,416 tons of steam is consumed in 2015 in the machine isolated with the silicone coated glass fiber and glass wool blended material, whereas 16,072 tons of steam was saved which corresponds to the approximately steam consumption of 3 months in the factory. PE material was used 18 months in the factory, and no deformation was observed. This also indicates the long-lasting property of PE based insulation material. On the other hand, the unit steam generation costs are 11.4 USD/ton steam generation via domestic coal and 22.73 USD/ton steam generation via natural gas. The annual cost savings for the steam generations are approximately 183 thousand USD if domestic coal with 4000 kCal/kg calorific value is used for the steam generation, whereas it is approximately 365 thousand USD if natural gas is used. The results also indicate that there was no change for cooling time and the amount of cooling water in the tested machines; there were all about 302 thousand liters and no recipe changes were needed that would affect the chemical consumption.

### Conclusion

In this study, silicone coated glass fiber and glass wool blended and highly cross-linked polyethylene foam manufactured insulation materials are compared for reducing the heat losses in textile dyeing machines in the context of the cost and energy saving potentials. The factory has used the silicone coated glass fiber and glass wool blended material on some of the dyeing machines and 26% of heat saving can be achieved. Totally 48 tons of fabric was dyed during 60 trials in the same process conditions of two types of isolation systems and a reference case of no isolated machine. The results indicate the energy saving potential seems similar for both isolation materials; however, for reducing the energy losses polyethylene foam material was determined as more long-lasting since after 18 months no deformation was observed, whereas glass fiber and glass wool blended material deformed after 12 months. Furthermore, PE material can be cleaned easily and the application is quite simple due to its adhesive property. Since the cooling time of the processes did not change, recipe changes were not needed. Correspondingly chemical consumption stayed same causing no cost increase. Energy costs can be reduced at least 15% annually after isolation which corresponds to 183 thousand and 365 thousand USD compared to coal and natural gas use, respectively.

The results of this study may contribute to mitigate the energy losses at dyeing machines used in the textile sector which is mentioned as the 3<sup>rd</sup> most energy-intensive sector with 16% of value added in Turkish production industry

(Alkaya and Demirer 2014, Ozturk, 2005, MoDev, 2014). Accordingly, the energy which is the main cost component of the manufacture can be reduced.

Since this is one of the initial studies on saving heat energy at dyeing machines also including cooling processes an important know-how is gained for the sector. These applications are intended to be representative to the similar factories. The results may also spread to the dye-houses in Turkey ensuring serious energy savings and may guide to the dyeing machine producers for the new design of the machines.

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