

Short Communications

An energy efficient re-reeling process for silk reeling industry to reduce deforestation

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The energy consumption of a conventional re-reeling machine is evaluated according to design of its construction, and the suitable conceptualized modification is advocated to reduce the consumption of firewood. It is found that the modified re-reeling machine is energy efficient showing 59.14% reduction in heat energy consumption in comparison to conventional machine, thereby reflecting considerably less firewood utilization in the process and reduce the deforestation.

Keywords: Deforestation, Energy, Firewood, Re-reeling, Sericin, Silk reeling

Silk reeling industry is energy intensive in all stages of production, like cocoon drying, cooking, reeling and re-reeling. Being cottage industry located mostly in villages and towns, the industry depends on firewood and different sources of agriculture residues for energy needs¹.

In a study, it has been found that silk industry consumes on an average 20 kg of firewood for the production of 1 kg raw silk (20/22 denier) in 10-basin multiend silk reeling unit. It is estimated that 1,45,000MT/year of fuel wood and 1,70,000MT/year of other biomass are consumed for the production of raw silk in India, as other commercial fuel sources such as coal and LPG² are not favoured due to limitation of price and environmental pollution. However, the level of energy consumption is high but energy efficiency is low at about 10% with the use of fuel wood and biomass².

The purpose of re-reeling is to make silk thread of continuous length into skeins for easy transportation by removing defects in the raw silk. In order to avoid gum spots being created otherwise by fusing moist sericin, the raw silk needs to be dried enough by

creating hot air inside re-reeling compartment. It is studied that raw silk contains water equal to about 5 times to its own weight during re-reeling process, i.e. 10 kg raw silk re-reeled contains 50 kg (liter) of water, which needs to be dried out from the silk in order to avoid the gum spots for further processing of raw silk. During the preparation of re-reeled skein, the silk thread crosses over the other thread making an appearance of diamond shape by lining of silk threads.

In the present study, the energy consumption of re-reeling process in the existing re-reeling machine is evaluated and suitable modification has been suggested for effective utilization of precious fossil energy, which is expected to prevent deforestation.

Conventional Re-reeling Machine

The energy management in the existing multiend reeling unit consists of 100 kg boiler for 10-basins multiend reeling unit^{3,4}. The firewood is used to fire the boiler for supply of steam for all activities of reeling, such as to heat water in reeling basin, to bring boiling water temperature for cocoon cooking and to heat the air in re-reeling machine. Around 200 kg firewood, mainly tamarind wood, is used to fire the boiler for 10-basins multiend silk reeling unit for the production of 10 kg raw silk (20/22 denier) per day. Energy required for cooking and reeling operation with the use of firewood has been studied⁵. In a further study, it has been observed that 1,19,920 kcal of energy is consumed in re-reeling process with the use of 86.52 kg firewood.

The schematic diagram of the existing re-reeling machine is shown in Fig.1. The surface area of the metal construction of the re-reeling machine measured is 19.68 m² and 1700 kg of iron is used to fabricate the machine. Average heat loss due to lack of insulation⁶ is reported as 2.7 kcal/m²/h. The inside temperature of re-reeling machine cannot be maintained at 45°C unless the iron body of machine turns to same temperature and counter the effect of energy loss due to cooling by radiation of heat energy through metal surface area. The energy required to maintain the iron components (mass) at 45°C throughout re-reeling process for 8 h (at ambient

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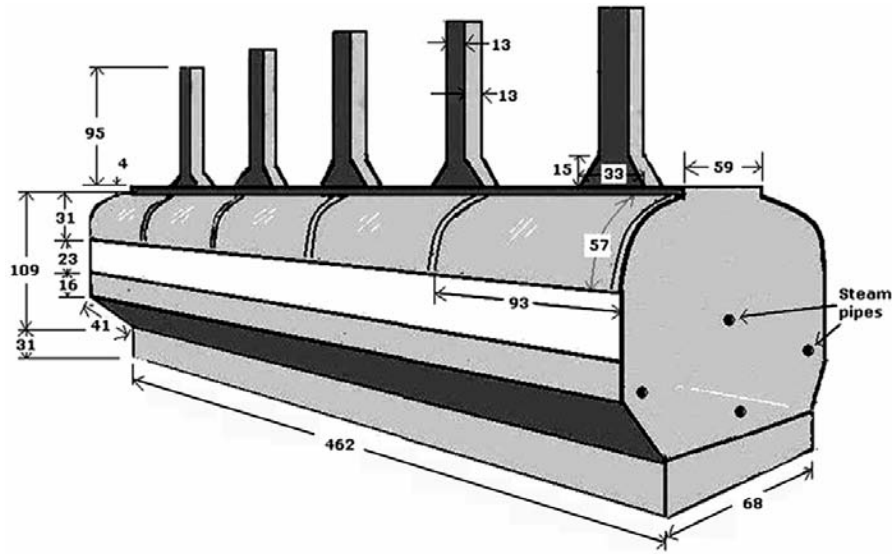


Fig.1—Existing re-reeling machine (measurement in cm)

temperature of 25°C) is 4,097.088 kcal considering specific heat of iron as 0.108 kcal (ref. 7). Energy required to take out 50 kg water moisture from 10 kg raw silk is around 3,000 kcal by considering specific heat of water at 1 kcal.

During the re-reeling process, the considerable amount of energy is thrown out from the re-reeling machine by rotational speed of 10-numbers of swifts through 5 chimneys fixed on the top of the re-reeling machine. The standard circumference of the swift rotating inside re-reeling machine is 1.5 m and it rotates at 180 rpm, producing 10 kg of (21 den) raw silk re-reeled. Each swift is composed of 6-numbers batterns of 5cm width and 60 cm length and while rotating the swift battern acts as fan leaf affecting mixing and throwing 7,33,165.71 m³ of hot air (density of air at 40°C is 1.128 kg/ m³ and specific heat is 0.24 kcal). By collusion and friction of air inside the re-reeling machine at median line of machine (Fig.2), a part of hot air (as rotating swift angle of 108° i.e 30% of 360°) gets out from the 5 chimneys losing 46,797.81 kcal of heat energy.

Thus, the total energy required to drive out the moisture of 50 kg water from 10 kg raw silk is 53,894.088 kcal of heat, which is equivalent to 38.885 kg of firewood. However, the transmission loss of steam is not taken into consideration, which is beyond the scope of this study.

Modified Energy Efficient Re-reeling Machine

During re-reeling process, raw silk carries water about 5 times to its own weight, which needs to be

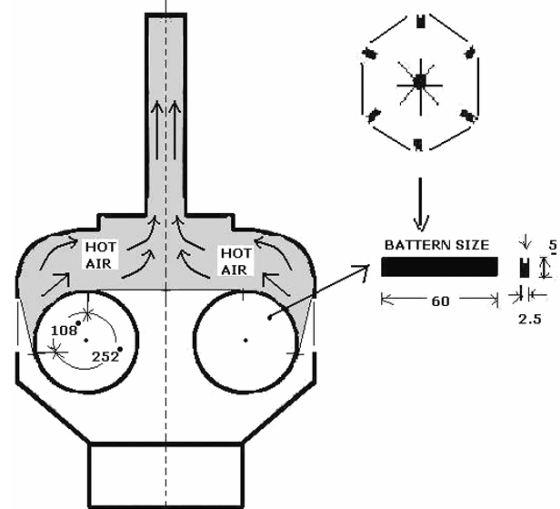


Fig. 2—Cross-sectional view of re-reeling machine and swift dried and re-reeled into skeins. While driving out moisture from the silk, water converts into water vapour. Whenever a water molecule leaves the surface, it is said to have evaporated and each individual water molecule that is converted into vapour takes a parcel of heat with it, leaving water body i.e. wet skein to cooler. Water vapour will only condense onto another surface when that surface is cooler than the dew point temperature⁸. The re-reeling machine works under atmospheric pressure and it is well known that in any gas, at a given temperature and pressure, the number of molecules present is constant for a particular volume (Avogadro’s law of gas theory). The high swift speed in the re-reeling machine displaces 7,33,165.71 m³ of hot air inside

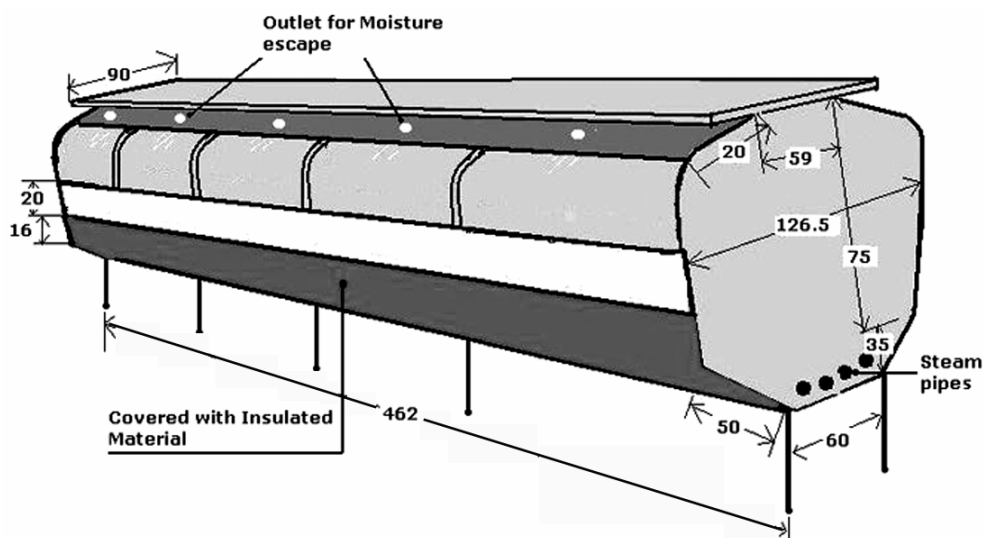


Fig. 3—Modified design of energy efficient re-reeling machine

re-reeling machine interacting with atmospheric air. The content of water vapour molecules evaporated from the silk is very less compared to huge quantity of air being displaced by swift speed and hence water vapour will be replaced easily by interaction of inside air with outside through a regulated small opening provided at the top of each swift, which is shown in Fig.3. This regulated outlet for moisture escape allows removing 10% of the hot air being present in re-reeling compartment. Thus, as per the proposed design, 5 chimneys being used for existing re-reeling machine (Fig.1) are not necessary, which leads excess heat loss. By removing the chimney, the weight of iron and manufacturing cost to fabricate re-reeling machine will be reduced apart from the reduced metal surface. This reduced metal surface area, in turn, yields to lesser energy consumption.

Further, in order to reduce the metal surface area of re-reeling machine, the bottom of the re-reeling machine is covered with a sheet of bad conductor of heat. This reduces the heat loss, which otherwise will be lost by heat radiation.

The energy saving from the modified energy efficient re-reeling machine is shown in Table 1. It is observed that the modified energy efficient re-reeling machine needs 22,023.88 kcal of heat energy in comparison to 53,894.088 kcal of heat energy in the existing re-reeling machine, thereby showing a reduction of heat energy to the tune of 59.14%. As per the proposed modification, there would be reduction in consumption of 22.995 kg firewood for production of 10 kg raw silk in 10-basin multiend reeling unit per day.

Table 1—Comparative statement of energy consumption by existing and modified re-reeling machines

Particulars	Energy consumption kcal	
	Existing machine	Modified machine
Energy required to remove moisture from raw silk	3000	3000
Energy required to maintain the iron components (mass) at 45°C (amb. temp. 25°C)	4,097.088	3,424.61
Energy lost through 5 chimneys	46,797.81	N.A.
Energy lost through small outlet to remove moisture	NA	15,599.27
Net energy utilized	53,894.898	22,023.88

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