# EXECUTIVE SUMMARY

## Title : Energy Conservation in Rubber Smoking Industry.

**Introduction :**

ASEAN-Australia Energy Cooperation Programme Phase II allocated an amount of A$ 47,400 to Prince of Songkla University, Hatyai, Thailand to commit a research work on energy conservation in rubber smoking industry. Assist. Prof. Dr. Suteera Prasertsan was assigned to lead the research team which comprises of Prof. Dr. Naksitte Coovattanachai, Assist. Prof. Gumpon Prateepchaikul, Assist. Prof. Samarn Sen-Ngam and Mr. Pirot Kirirat.

Eighty percent of the rubber products of the country is smoked rubber. The original objective of the project was to reduce energy used by the rubber smoking industry. Energy consumed by the process is heat for drying and curing. Rubber wood is the only source of energy. Hence, the project aimed at reducing fuelwood consumption by improving thermal efficiency of the process.

**Research Activities Accomplished :**

**Field Survey :**

A survey of 25 rubber smoking factories was done to acquire the technologies employed and firewood consumed. It was found that there are two types of smoking rooms called single-layer and double-layer rooms. The furnance can be either outside or underneath the room but the outside furnace is more desirable for safety reason. Smoking time for the single-layer room is 5 days in average which is 2 days shorter than that occurs in the double-layer room. Firewood cost is 128 Baht*/$m^3$ (April-May 1991). The specific wood consumption was 0.25 and 0.38 $m^3$ per ton of rubber for the single-layer and double-layer rooms, respectively. The corresponding specific fuel costs were 30.7 and 49.0 Baht/ton which were relatively insignificant compared to the raw material price (about 17,000 Baht/ton). It was estimated that $1.7 \times 10^6$ $m^3$ of firewood is available annually from the rubber

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* Exchange rate B25 = US $1, B17 = A$1

plantation (replanting scheme after 25 years of economical life time). Firewood required by the rubber smoking industry is $202 \times 10^3$ $m^3$/year. It is obvious at this point that an attempt to conserve the firewood for this industry is not justified.

Monitoring of Rubber Smoking Process.

In order to understand the process, the research team committed a monitoring of the rubber smoking process. Energy and mass balance was analysed. The results was summarized below.

There are two factors controlling the smoking process, namely heat and surroundings humidity. The smoking room of 45 tons capacity requires heat of 20,120 MJ during a 116 hr operation. Only 31% of the input energy was useful. The rest was the losses through conduction (57%) and ventilation (11.8%). Energy saving measure by application of thermal insulation was not recommened since financial benefit was not attractive enough. Water inherent in the exhaust gas was found to be 4.2 tons of which 2 tons, 1 ton and 1.2 tons could be derived from inlet air, the firewood and the rubber, respectively. It is anticipated that the dehumidification of the inlet air will significantly increase the productivity by decreasing the processing time.

Study of Factors Affecting the Curing of Rubber Sheets.

Monitoring of the smoking process in the previous section resulted in a study leading to understand the effects of inlet air humidity, air flow rate and loading density on the curing behaviour of the rubber sheets.

Experiments were carried out on batches of 15 kg rubber tested in an environmentally controlled chamber. Parameters designed for the study were relative humidity (RH) of inlet air, air flow rate and loading density (kg of rubber/$m^3$ of chamber). Results showed that curing time for the experiments with 60%, 40% and 20% RH were 76.6% (54 h), 59.6% (42 h) and 50% (36 h) of that required for the 80% RH experiment (70.5 h), respectively. Air flow rate has little effect on the curing time. Curing time with loading density of 63.23 kg/$m^3$ (same

figure as in factory) and at relative humidity of 40% was found to be 45 hours which is only 40% of the smoking time in a full scale smoking room.

Two experiments were carried out simultaneously in two smoking rooms fired with green firewood and dry firewood to verify the effect of moisture in the firewood. Adverse effect of moisture in the firewood was proved. The processing time for the dry-firewood room was approximately one day shorter than that of the green-firewood room.

**Preliminary Study on Heat Pump Air Drier.**

Heat pump is the technology selected for air drying purpose. The cost of implementation is moderate compared to other technologies and the operation and maintenance of the unit are rather simple. Dehumidification of air by a heat pump is a common practice in many low temperature drying industries, e.g., food and pharmaceutical products. Preliminary study was carried out on a one ton (refrigerating capacity) unit. Data gathered from this experiment was used to design and select components to construct a full scale unit. A 3.6 ton unit was constructed and installed to the furnace of a smoking room. Experiment was performed and revealed a promissing shorter processing time. The unit cost is acceptable (by the factory's owner) but the operating cost has yet to be reduced. It was expected that at least 10 kg/h of water can be extracted from the inlet air. The actual experiment gave only 6 kg/h, though. Performance of the evaporator has to be improved.

It is recommended that limitations of the demand side must be realized before commencing a research leading to the development of a viable air drier. Market survey is the recommended tool to achieve knowledge of the demand side. Application of air driers in drying of energy-sensitive products or high value products should receive attention in order to expand the market.

## PUBLICATIONS DERIVED FROM RESULTS OF THE PROJECT.

### Journal contribution

1. Prasertsan, S., G. Prateepchaikul, N. Coovattanachai, P. Kirirat, S. Nakgul, P. Honghiranrueng and P. Ngamsritragul, Wood Utilization in the Smoked Rubber Industry : Southern Thailand Case Study, RERIC Int. Energy J., Vol 13, No. 1, 1991, pp. 19-28.
2. Prasertsan, S., P. Kirirat, S. Sen-Ngam, G. Prateepchaikul and N. Coovattanachai, Monitoring of Rubber Smoking Process, RERIC Int. Energy J., (in press for June 1993 issue).
3. Prasertsan, S., P. Kirirat and S. Sen-Ngam, Factors Affecting Rubber Sheet Curing, RERIC Int. Energy J., (accepted, being revised)
4. Prasertsan, S., S. Sen-Ngam and P. Kirirat, Heat Pump Air Drier Assisted Rubber Smoking Process., in preparation for submission to RERIC Int. Energy J.

### Conference and workshop

1. Prasertsan, S., Rubber Smoking Industry :- The Technology and Firewood Used, Int. Conf. Energy Conservation in Industries, Ubon Ratchathani, Thailand, 11-14 June 1991.
2. Prasertsan, S., N. Coovattanachai, P. Kirirat, S. Sen-Ngam and G. Prateepchaikul, Predehumidification of Combustion Air :- An Alternative for Rubber Smoking Industry, A paper presented at the ASEAN-EC Cogen Workshop, Medan, Indonesia, 5-7 Oct 1991.
3. Prasertsan, S., S. Sen-Ngam, P. Kirirat and N. Coovattanachai, Energy Auditing of a Rubber Smoking Room, Proc. 3$^{rd}$ ASEAN Science and Technology Week, Singapore, 21-23 Sept 1992, pp. 184-187.
4. Prasertsan, S., P. Kirirat, S. Sen-Ngam, G. Prateechaikul and N. Coovattanachai, Monitoring of Rubber Smoking Process, Proc. Conf. on Energy, Bangkok, 26-27 Oct 1992, pp. 100-110.
5. Prasertsan, S., Strategy for Rubber Smoking Industry :- Less wood consumption and higher productivity, in preparation to be presented in 5$^{th}$ ASEAN Conference on Energy Technology, Bangkok, 25-27 April 1994.