



## Executive Summary

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The “Research and Development of Rubber and Parawood Products Under the Cooperative Network of Manufacturers and Research Units” Project was started in 2013 by the Office of Industrial Economics (OIE), Ministry of Industry with the Rubber Technology Research Centre (RTEC), Faculty of Science, Mahidol University acting as coordinator and manager of the Project. The Project arose from the realization of the OIE that there existed problems with rubber products research and development (R&D) in Thailand. Most of the R&D work could not be applied for the benefits of the rubber and parawood products industries. Lack of opportunity to meet and discuss about the actual industrial problems between researchers and manufacturers is believed to be the main cause of the problems.

Therefore, research and development support in the form of cooperative network of manufacturers and research units is believed to be the way to alleviate this problem. The expected outcomes of the project are:

1. Existing products or manufacturing processes which are improved or new products developed from R&D can be applied for commercialization.
2. There are continuous R&D on rubber and parawood products which can generate technology and product innovation according to the needs of the industry. As a result, the

competitiveness of the Thai rubber and parawood products industry will be enhanced, leading to increase of income from export of rubber and parawood products for the country.

## 1. Past performances

### 1.1 Activities in the first year (2013)

The “Network for Development of Rubber and Parawood Products Industries” was established under the coordination and management of the Rubber Technology Research Centre (RTEC), Faculty of Science, Mahidol University. The activities which were carried out in the first year, were related to development of the infrastructure of the Network. These include,

1.1.1 Preparation of R&D plan for the network

1.1.2 Preparation of rubber and parawood products R&D roadmaps

1.1.3 Establishment of R&D database for rubber and parawood products implemented in Thailand

1.1.4 Knowledge management to support R&D of the network

1.1.5 Preparation of website of the Network

1.1.6 Research and development of technologies for production of rubber and parawood products including production technology for oil-resistant solid tire for forklift truck and preservation technology for parawood.

## **1.2 Activities in the second year (2014)**

In the second year, the R&D needs of the network members as well as those of other rubber and parawood products manufacturers and the training and seminar needs for enhancing abilities of the network members were surveyed. Moreover, survey of the R&D capabilities in the academic institutes and industries were done. The following conclusions were obtained which would be used a guideline for devising the activities of the network,

1.2.1 Most of manufacturers require their R&D projects to be “closed” ones. They prefer to do their own R&D within their company and do not want to unveil their research topics to the public. However, they still require R&D consultancy support.

1.2.2 Most of university researchers have the opinions that they are ready to do industrial R&D but do not know the R&D needs of the industrial sectors. They would like the Rubber and Parawood Products R&D Network to inform them of the R&D topics required by the industry.

1.2.3 Technical personnel in the industrial sectors may not be sufficiently trained to be engage in R&D. The qualifications of industrial personnel are bachelor degree or lower.

Furthermore, the Network also organized knowledge and technology transfer activities for their members including training courses, technical seminars and publications of technical articles and bi-monthly newsletter. For R&D project which met the need of the industry, the project “Quality improvement of white solid tire” was completed according to the need of V.S. Rubber Industry, Co., Ltd.

### **1.3 Activities in the third year (2015)**

The third year activities emphasized promotion of interactions among members of the Network as well as related persons in order to create opportunity for R&D collaboration and possible commercializable products.

1.3.1 Organization of relevant training courses on rubber and parawood technologies.

1.3.2 Organization of technical seminars to disseminate scientific and technical knowledge to members of the Network.

1.3.3 Organization of focus group meetings to share knowledge and experience.

1.3.4 Organization of site visits to manufacturing factories and academic institutes.

1.3.5 Updating database of knowledge, technology and R&D of rubber and parawood products from the first and second year.

1.3.6 Production of up-to-date technical articles.

1.3.7 Continuing rubber clinic to provide technical consultation via telephone call, e-mail or appointed meeting.

1.3.8 Updating the Network website as a tool for communication among members and dissemination of information, knowledge and technology.

1.3.9 Publishing bi-monthly newsletters.

1.3.10 Survey of the R&D needs of manufacturers in the rubber and parawood products industry and coordinate to develop R&D project proposals to be applied for R&D funding from research

funding agencies such as the Thailand Research Organizations Network (TRON). Two research proposals have been drafted for this year; (1) Research and development of new coagulant as replacement for acetic acid in the production of rubber thread (2) Development of highly durable solid tire.

1.3.11 Research and develop outputs according to manufacturers' needs i.e. "Development of Technology for Automatic Detection of Defects in the Production Line of Rubber Thread". The project was done in collaboration with Thai Filatex Public Company Limited.

#### **1.4 Activities in the fourth year (2016)**

The fourth year activities comprise existing activities according to the needs of the members of the Network and new activities which would lead to more applicable research output.

1.4.1 Development of knowledge and skills of members of the Network

1. Organization of relevant training courses on rubber and parawood technologies according to industry's needs. The objective is to develop knowledge and skills of workers in the rubber and parawood industry.

2. Organization of technical seminars to disseminate scientific and technical knowledge to members of the Network.

3. Production of up-to-date technical articles about rubber and parawood products.

4. Operation of rubber clinic to provide technical consultation.

1.4.2 Promotion of communication and interactions among members

The activities supported interactions among members, exchange knowledge, views, and experiences as well as providing opportunity for members to become familiarized with one another. This may lead to cooperation in R&D within the Network. The activities comprise,

1. Organization of focus group meetings to share knowledge and experience.
2. Organization of site visits to manufacturing factories and academic institutes.
3. Updating the Network website
4. Publishing bi-monthly newsletters.

1.4.3 Rubber information support

The rubber and parawood researchers database including existing rubber products and parawood research database were updated. Database of rubber knowledge and technology were developed which include articles about rubber and parawood products. The database were disseminated via the Network website.

1.4.4 Promotion of research in the rubber products industry

The R&D needs of manufacturers in the rubber and parawood products industry were surveyed by direct communication or site visit. Coordination to develop R&D projects including finding researchers and research funding sources were made. Assistance to

develop research proposals for applying to research funding agencies such as the Thailand Research Organizations Network (TRON) was also made.

1.4.5 Research and development to produce applicable outputs

R&D projects were carried out with manufacturers in the rubber and parawood products industry on the subjects of their choices in order to be certain that the research outputs would be applicable for the benefits of the industry. Researchers and some financial supports were provided with expected partial financial contribution from the industry.

1.4.6 Evaluation of past research work

Past research work which were financially supported by research funding agencies such as TRF or NSTDA and have not been utilized were re-evaluated to select ones that have potential for commercialization. Support would be provided to develop those selected projects further with the consent of the original project investigators and the research funding agencies.

1.4.7 Setting-up of pilot research consortium

Research consortium comprises manufacturers of rubber and parawood products who are interested in R&D and are willing to invest in R&D will be set-up. The objective of this consortium is to produce R&D output which can benefit more than one manufacturer. This is believed to be the way to accelerate the development of the rubber industry.

### 1.4.8 Plan for development of manpower in the rubber product industry

This was a follow-up activity from last year’s focus group meeting on “Development of Manpower in Rubber Industry” which revealed shortage of rubber manpower in both the government and the industrial sector in both production and R&D. This problem hinders the development of the rubber products and parawood industry.

## 2. Output of the Project

The output of the project in 2016 went according to plan and is summarized in Table 1.

**Table 1** The Project Output

Activities	Plan	Output
1. Training courses on rubber and parawood technologies	3 courses Minimum 40 participants/course	4 courses Minimum 40 participants/course
2. Training course documents	3 documents	4 documents
3. Technical seminars	At least 3 seminars Minimum 200 participants	3 seminars 283 participants
4. Technical articles on rubber technology	At least 3 articles	3 articles

Activities	Plan	Output
5. Rubber clinic	At least 20 consultancy services	22 consultancy services
6. Focus group meetings	At least 3 meetings	3 meetings
7. Site visits of factory and academic institute	At least 2 site visits	2 site visits
8. Improvement of network website	1 website	1 website
9. Bi-monthly newsletters	6 newsletters	6 newsletters
10. Updating of database for rubber and parawood researchers	1 database	1 database
11. Updating of database for rubber and parawood R&D	1 database	1 database
12. Assessment of completed R&D projects	At least 2 projects	4 projects
13. Setting-up of Pilot Research consortium	1 consortium	1 consortium

Activities	Plan	Output
14. Plan for manpower development in the rubber product industry	1 report	1 report
15. R&D proposals	At least 2 proposals	3 proposals
16. Applicable R&D outputs	At least 1 output	1 output

Details of the Project outputs,

## **2.1 Training courses on rubber and parawood technologies**

Four training courses on rubber and parawood technologies as required by manufacturers were organized as shown below.

### **2.1.1 Thermoplastic elastomers and applications**

Thermoplastic elastomers (TPEs) are rubbers that can be shaped like thermoplastics, by injection molding or extrusion. Therefore, TPEs can be made into products rapidly and in mass without having to be vulcanized like conventional rubber products. TPEs are increasingly being used to manufacture rubber parts because of the advantages of low production cost and can be made into colorful products. The trend in the rubber products industry is towards the uses of TPEs.

### **2.1.2 Vulcanization of rubbers to meet required properties**

Normally, rubber cannot be used as a product if it is not vulcanized. Vulcanization is the process which makes rubber stronger, more elastic, with improvements in heat and chemical

resistances. Knowledge and technology of vulcanization is, therefore, important if the required rubber properties are to be obtained.

### 2.1.3 Quality Control of Rubber products Manufacturing

“Quality” of products and services is important and is one of the main consideration worldwide. This course emphasizes understanding of the “Quality” concept and how it can be applied to control and improve products and services in order to achieve uniformity in quality, lowering of defects, increase productivity and lower the cost.

### 2.1.4 Forest Legistration Applied to Parawood Industry

Currently importers especially in Europe and USA, have important measures both directly (law) and indirectly (regulation/condition of buyer or importer) to import sustainable wood products. To ensure and support the measures of lower environmental damage and good management, the imported products must be traceable to original source and supply chain. This objectives of this course are for parawood manufacturers to study and understand laws, regulations and directions of licensee for lumber and wood products including manufacturing procedures and management.

## 2.2 Technical seminars

Three technical seminars were organized as shown below,

### 2.2.1 New Methods for Characterization of Modified Natural Rubber

Characterization of natural rubber is important for R&D. Although several characterization methods exist, there have always been new development of techniques and equipment which would allow better characterization of materials. This seminar focused on new techniques for characterization of modified natural rubber including Focused Ion Beam Scanning Electron Microscopes (FIB-SEM), Three-dimensional Transmission Electron Microscopy (3D-TEM), and Field-gradient Nuclear Magnetic Resonance (FG-NMR).

### 2.2.2 Preparation for Certified Standard of Sustainable Parawood products management PEFC-COC

Parawood products are one of Thailand's high potential exported products. Currently, the global wood market is highly competitive. Purchasing condition is normally set by customers. The wood to be purchased must comply with international standards for sustainable management including FSC and PEFC-COC. This seminar provides training on the preparation for export of parawood products in line with international PEFC-COC. This is to enable manufacturers to compete with other woods in the world market.

### 2.2.3 Uses of Rubber Products in Military

The policy of the Government is to promote domestic uses of natural rubber, especially for military applications. In the past, manufacturers and researchers have not been informed of the military needs of rubber products. This seminar provides

a forum for learning about the rubber products that are needed by the military. These can become R&D topics of the network that can support military uses of rubber products.

## **2.3 Updated technical articles on rubber technology**

Three technical articles were produced as follows,

### **2.3.1 Why is S-SBR Suitable for Production of Green Tire ?**

Solution Styrene-Butadiene Rubber (S-SBR) is a new type of SBR that is produced by solution polymerization. Its properties is suitable for making a fuel-saving tire and good wet-grip because of unique molecular structure. Therefore, the uses of S-SBR is steadily increasing.

### **2.3.2 Understanding of Adhesion for Improved Applications**

Adhesion between surfaces of materials is important in product manufacturing of small or large engineering structures. The basic knowledge involved is chemistry. This article describes adhesion mechanisms, both mechanical and chemical, problems and solutions, and treatment of surfaces to be bonded.

### **2.3.3 Fillers for Energy-saving Tires**

Trends for tire development are energy-saving tires, lower noise tires and good wet-grip tires. These properties depend on a large part on compounding formulations. This article presents about fillers which affect the two main properties, i.e. fuel-saving and road grip.

## **2.4 Rubber clinic**

There were 22 consulting cases – 3 cases by e-mail, 12 cases by phone, and 7 cases by walk-in meeting. The consultations are concerned with production technology, problem solvings, compound development, information on rubbers, properties and their applications, product standards, rubber experts and R&D of NR products.

## **2.5 Focus group meetings**

Three focus group meetings were organized.

### **2.5.1 “How does research help develop the company?”**

Industrial manufacturers who realize the importance of research and development and have actually benefited from successful R&D work were invited to speak at this focus group meeting. The objective was to stimulate interests in R&D among rubber and parawood products manufacturers, 90% of which are small and medium enterprises (SMEs). Successful research work requires interest and commitment from the company. Without this, it will be difficult for research to be successful despite an existence of mechanism for networking between researchers and manufacturers.

### **2.5.2 “Development of manpower in rubber industry”**

The objective of this meeting was to seek methods for development of manpower in the rubber industry, to support the expansion of the rubber industry. Presently, there is still shortage of manpower in the industry in terms of both number and the quality.

### 2.5.3 “Can Thai rubber glove Industry become world’s No.1 ?”

Thailand is the second producer and exporter of rubber gloves in the world after Malaysia. However, Thailand is the world's No.1 latex producer and exporter. Therefore, it is interesting to find out whether the Thai rubber glove industry can become the world's No.1 manufacturer of rubber gloves. This focus group meeting was organized as a forum for discussion and exchange views among key persons from both the government and private sector. The essences of the meeting are that the competitiveness of the Thai rubber glove industry is lower than that of Malaysia. Furthermore, expansion of the industry and modernization of technology would require high investment. Since the Thai glove manufacturers are mostly small and medium size enterprises (SMEs), they cannot afford such high investment and will still need support from the government for investment, research and innovation.

## **2.6 Site visits of factory and academic institute**

Two site visits were organized as follow,

2.6.1 Thailand Automotive Institute

2.6.2 Bangkok Synthetics Elastomers (BSTE)

## **2.7 Updating of network’s website**

The website of the network (<http://rubber.oie.go.th/rrd>) was updated;

## **2.8 Bi-monthly newsletters**

Six bi-monthly newsletters were produced as follow,

2.8.1 Newsletter Vol. 2, No. 5, October 2015

2.8.2 Newsletter Vol. 2, No. 6, December 2015

2.8.3 Newsletter Vol. 3, No. 1, February 2016

2.8.4 Newsletter Vol. 3, No. 2, April 2016

2.8.5 Newsletter Vol. 3, No. 3, June 2016

2.8.6 Newsletter Vol. 3, No. 4, August 2016

## **2.9 Updating the database of rubber and parawood researchers**

The database of rubber and parawood researchers and lists of the network's experts were updated and disseminated on the network's website.

## **2.10 Updating of database for research and development of rubber and parawood products**

The database for research and development of rubber and parawood products were updated. Database of patent of rubber threads was also added. The database was posted on the network's website.

## **2.11 Selection of completed research projects funded by NSTDA and TRF for further development**

Four completed research and development projects granted by TRF and NSTDA which have not been exploited but have

potential to be further developed were selected. These projects will be recommended for further development.

2.11.1 Use of microwave technology in the rubber industry.

Use of microwave can save energy in rubber manufacturing process. Therefore, further support of research and development of this technology should be made. Potential benefits are warming of thick rubber parts or drying of rubber sheets and blocks.

2.11.2 Production of concentrated latex by creaming process for community scale manufacturing of rubber products.

Concentrated latex produced by creaming method is already used in the industry but for special products which do not require large supply of concentrated latex. This is because creaming of latex is a slow process and long time is required to produce concentrated latex. However, the process does not require expensive centrifuging machines, thus is suitable for production of small scale concentrated latex. Research and development of concentrated latex by creaming method and product development should be extended and transferred to rubber farmers or cooperatives.

2.11.3 Comparative study of Thai motorcycle tires and of their competitors.

The project should be extended to improve the quality of Thai motorcycle tires while lowering cost by using reclaimed rubber.

#### 2.11.4 Comparative study of Thai bias truck tires

The project should be extended to improve the quality of Thai bias truck tires as it will benefit Thai SMEs.

### **2.12 Setting-up of Pilot Research consortium**

A research consortium has been set-up which is known as “Progressive Rubber Research Group”. Manufacturers who show interests in research and are prepared to invest in research were invited to join the Consortium. The “Progressive Rubber Research Group” will not work only in research but will consider marketing and human resource development also.

### **2.13 Plan for manpower development in the rubber product industry**

Plan for human resource development in the rubber product industry was prepared. Problems of manpower in the rubber industry and solutions suggested are shown below.

#### 2.13.1 Problems

(1) There is shortage of manpower in both quantity and quality. Newly recruited manpower cannot work according to the requirement of the industry. They have to be given training before they can work to the expected level.

(2) Most recruited staffs can only work as instructed. They cannot adapt or solve the problems by themselves. The work attitude is also poor. The turnover of the workforce is high.

(3) There are increasing number of foreign workforce. Communication becomes a problem which also affect everyday operation.

#### 2.13.2 Solutions

(1) Improvement of rubber course curriculum in colleges and universities should be encouraged. Cooperative education should be promoted as alternative to improve working skills. Qualified persons in the industry should be invited to participate in teaching of the rubber courses. Infrastructure, especially equipment, should also be improved.

(2) Promote and support establishment of units which provide training service in rubber technology and other areas required by the industry such as management, standards and safety. This is to support the needs of the industry for on-the-job training before staffs can effectively work in the factory.

(3) Establish an organization which oversees the development of manpower in the industry. This may be in the form of association composed of manufacturers, academic persons, and other relevant people. This responsibilities of this organization are to organize short course training, standard rubber courses and teaching media. This organization will also be a meeting place for stakeholders to discuss and work together to try to improve the quality of the workforce to meet the needs of the industry. Similar organizations exist in other countries such as the Plastics and Rubber Institute of Malaysia or the Indian Rubber Institute.

## **2.14 Development of R&D proposals**

Three research and development proposals were developed and planned to be submitted to the funding agencies.

### **2.14.1 Research and Development of Solid Tires.**

To support development trends of solid tires which are smaller and lighter-weight tires.

### **2.14.2 Research and Development of Non-pneumatic Tires.**

To support development of non-pneumatic tires which are expected to be commercially important in the future.

### **2.14.3 Natural Rubber-Parawood Powder Composites.**

Natural rubber-Parawood composites are interesting new materials which have not been extensively studied. Therefore, their study may provide opportunity to develop innovative applications of natural rubber.

## **2.15 Research and development to produce applicable outputs**

An applicable research and development output, “Development of Finger Cot Production”, has been developed in collaboration with D-Rubber Products, Co. Ltd.

The problem of surface resistivity being higher than product specification was solved by adjusting chlorination condition of the product. The other production problem was poor adhesion of carbon black with the rubber, resulting in loss of carbon black powder from the fingercot. It was found that adjusting the chlorination conditions or reducing the sizes of the dispersed carbon

black could not solve the problem of debonding of carbon black. Further study will be made on the dispersion of carbon black in the rubber and also the carbon black – rubber interactions. Poor dispersion of carbon black before adding to the latex and poor adhesion can lead to debonding and loss of carbon black from the fingercot.

## **2.16 Suggestions for Further work**

From results of the work done in 2016, some of the outputs should be developed further to obtain eventual benefits. These are,

### **2.16.1 Research projects**

The finished and unutilized research projects granted by TRF and NSTDA were evaluated and suggested for further development. Others are projects which were developed according to the requirements of the manufacturers. These research projects should be developed further.

#### **(1) Completed and unexploited research projects**

(1.1) Uses of microwave technology in rubber industry

(1.2) Production of concentrated latex by creaming method for small scale production of rubber products.

(1.3) Improved utilization of reclaimed rubber for manufacturing of better quality motorcycle tires.

(1.4) Improvement of bias tire technology to produce better quality bias tires.

(2) Research project proposals to be applied for funding

(2.1) Research and Development of Lighter Solid Tires.

To be collaborated with V.S. Rubber Industry Co., Ltd.

(2.2) Research and Development of Non-pneumatic Tires.

To be collaborated with Siam Rubber Industry Co., Ltd.

(2.3) Natural Rubber-Parawood Powder Composites.

To be collaborated with M.B.J. Enterprise Co., Ltd.

2.16.2 Development of manpower in rubber product industry

Apart from the recommendation to improve rubber technology course syllabus in academic institutes to meet the requirements of the manufacturers, there are other activities which should be carried out, as shown below.

(1) Promotion of rubber training services in accordance with the needs of the industry.

(2) Establishment of an organization to oversee the development of manpower for the rubber industry. This may take the form of association with representatives from private and academic sectors as working members.

### 2.16.3 Development of pilot research consortium

The pilot research consortium known as “Progressive Rubber Research Group” has been set up. It comprises three companies. This project should be continued.

## 2.17 Recommendations

Since the “Research and Development of Rubber and Parawood Products under the Cooperative Network of Manufacturers and Research Units” Project will end this year in 2016, the following recommendations can be made.

2.17.1 The establishment of the Rubber and Parawood Products Network which has been in operation for 4 years generated the following benefits,

(1) The real needs of the manufacturers in the rubber and parawood products industry are known. Therefore, measures to support the development of the industry can be more effectively implemented.

(2) Interests in research and development have been instilled into the rubber and parawood products manufacturers. R&D is important for development of competitiveness of the SMEs.

(3) The manufacturers who are interested in research and development but cannot do it by themselves because of lacks of research support information are provided with the necessary information.

Because of the many benefits given by the Network, the activities of the network should be continued because successful commercialisable industrial R&D requires not only high budget but continuous efforts.

2.17.2 The method of management of Rubber and Parawood Products Network may have to be changed because of a cut in the budget previously supported by the government. The Network may decrease in size and is limited to those who are interested in joining the Network as paid members. The operation of the Network may be in the form of,

(1) Association managed by members.

(2) Research consortium which has been set up this year.

From the two suggested future forms of the Network, participating members will have to financially support the operation of the network. For this reason, the size of the Network may be smaller and involves only manufacturers who are really interested in R&D and are prepared to invest in research.



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