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15954

DP/ID/SER.A/775
13 November 1986
ENGLISH

STRENGTHENING OF THE CHINA RAMIE TECHNOLOGY DEVELOPMENT CENTRE

DG/CPR/85/057/11-02

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(R) CHINA:

Technical report: Modernization of ramie degumming and related processes for the ramie industry. ~~(first mission)~~*/

Prepared for the Government of the People's Republic of China
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Chien Chu
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United Nations Industrial Development Organization
Vienna

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V.86-62005

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Explanatory notes

Local currency value:	1 RMB equals $0.27
RTDC	Ramie Technology Development Center
HRTERI	Hunan Ramie Textile Research Institute
RRI	Ramie Research Institute

ABSTRACT

The project was to assist the Government of the People's Republic of China in establishing the Ramie Technology Development Center for modernization of the ramie industry in the country. The expert served a period of one month (1) which started Spet.16, 1986 to Oct. 20, 1986. Two(2) organizations coordinated in carrying out the experimental work of the project.

1. The Hunan Ramie Textile Research Institute for laboratory testing experiments
2. The Ramie Research Institute, Hunan Agriculture College for supplying fresh ramie stalks for degumming experiments.

Main Conclusions

1. Modernization of fiber production techniques for higher yield and better quality can be attained by degumming ramie in the green stste. Production of stapled fiber in ramie growing areas should be established.
2. Degumming test of fresh ramie ribbons with ammonium solution containing sodium sulfite followed by soaping and peroxide bleaching produced degummed fiber with quality comparable in strength with the conventional two-stage caustic soda degumming process.
3. Biological degumming od stapled fiber followed by soaping and peroxide bleaching has good prospect for farm production of degummed fiber.
4. The existing 2-stage caustic soda degumming for dry crude fiber can be modified by stapling the fiber before degumming. A 2-stage degumming features 1% caustic soda with 0.1% sodium hexa-metaphosphate for ½ hr. at 2.8 kg/cm^2 in the first stage followed by acid washing in 0.2% hydrochloric acid for 10 minutes at room temperature. The second stage degumming was completed in ½ hr. in a soap solution containing 1% soap,

0.1% sodium hexametaphosphate, and 0.2% tea seed oil under mild pressure of 1.5 kg/cm^2. The degummed fiber was bleached in 3-stage peroxide process consisting of acid washing with 0.1% hydrochloric acid for 10 minutes at room temperature, 0.5% hydrogen peroxide with 1% sodium silicate for bleaching in 30 minutes at 80°C, and final rinsing with 0.2% acetic acid for 10 minutes at room temperature. The above modified degumming process gave higher yield of bleached fiber than the existing 2-stage straight caustic soda process. Mill test should be made after further laboratory study of this process.

INTRODUCTION

L. Ramie - A Miraculous and Tantalizing Fiber

Ramie fiber has long been a subject for enthusiatic predictions, few if any of which have been realized. As a consequence, there has been much elaboration in the trade about the great advantages that ramie fiber possesses over most of the other fibers in regard to tensile strength, luster, resistance to rot and mildew, high absorbency, rapidity of drying, and great increase in tensile strength when wet. On the other hand, much has been written on such disadvantageous properties as stiffness and lack of cohension, which combination always means brittleness.

Extraction of the crude fiber from ramie stalks and its degumming in natural length have encountered much difficulties due to high labor demand in washing and high cost of degumming chemicals besides pollution of waste degumming effluents.

Conventional processing of fully degummed fiber in its natural full length through beating, carding, drawing and combing has produced large amount of waste fiber, which makes ramie tops expensive.

2. Project Background

Hunan, a province of the People's Republic of China has an established ramie textile industry. The industry is based on production of crude ramie fiber in villages by manual stripping and scraping. Since the

founding of the People's Republic of China, the state has constructed three large modern ramie textile mills and several small mills. The ramie industry has about 110,000 spindles and 2,500 looms. The Provincial Hunan Ramie Textile Research Institute was established in 1979 with laboratory testing equipment and pilot spinning and weaving facilities. The Institute provides official testing services for the provincial textile industry. Much research work on ramie spinning has been made in the pilot plant with a modified cotton spinning system, which can accommodate medium length fiber over 3" in length.

Crude ramie fiber production in China will soon reach 140,000 tons, in which Hunan province contributes about 40 percent. Most of the ramie products such as crude fiber, degummed fiber, combed tops, yarn, grey sheetings and fabric are for export. Recent price of ramie/polyester yarn is about $3.3 per kg. However Production cost is very high. To earn one U.S. dollar of foreign exchange will cost almost 8 RMB. The current export of crude ramie fiber is a loss due to high cost of rural manual production in the traditional way. Ramie mills and exporters are competing for purchase of crude fiber. It indeed raised the price of crude fiber from 2 RMB per kg in 1984 to 12 RMB per kg in 1986. Ramie acreage expands rapidly.

Modernization of fiber extraction and degumming the fiber appear imperative. The Government has consolidated ramie export through organization of a Hunan Ramie Textiles Import & Export Corporation. The Corporation will improve ramie export with emphasis on quality control and stabilization of export price.

Hunan has the appropriate climatic, social and economic conditions necessary for the modernization of the ramie industry. Strengthening the existing Hunan Ramie Textile Research Institute in combination with the Hunan Ramie Research Institute of Hunan Agriculure College for agronomic research to the level of national ramie research organization known as Ramie Technology Development Center, is the purpose of the project.

3. Project Development

The request for United Nations assistance was initiated by the Hunan

Ramie Textile Research Institute in 1983. The project was approved in 1985 and became operational in 1986 under UNIDO program.

The cooperating agency was the Hunan Ramie Textile Research Institute supported by all ramie spinning mills in Hunan. The Ramie Research Institute of Hunan Agriculture College also rendered assistance for supply of fresh ramie for experimental work.

Besides seven(7) experts to be recruited for spinning, weaving, finishing, testing and training, the project requires one degumming expect for one months in four split missions of one month each, spread over four years.

4. Objectives

A. Objectives

a) Increase fiber yield of degummed ramie harvested in the region (reduced amount of noils);
b) To decresse cost of the degumming process by at least 25%;
c) To establish fibre grading system allowing an increase in the output of fine pure ramie tops;
d) To develop new additives for an improved and efficient degumming processing technology.

B. Training

To assist in providing training courses, lectures and seminars for industry staff, organized by the Training Unit of the Centre on subjects such as

- degumming technology;
- bio-degumming;
- new additives/oils for accelerated degumming;
- fibre preparation for industria. processing;
- cost comparisons of alternative degumming methods.

C. Dissemination

To suggest a mechanism for effective dissemination of research developments to industry and for consultancy services to industry in degumming.

I. RECOMMENDATIONS

Development Objectives

1. Coordination of HRTRL with PRI of Hunan Agriculture college for segragation of ramie varieties in cultivation and mechanical harvesting of ramie stalks as stapled stems or fresh ribbons will facilitate fresh degumming.
2. Development of modern ramie harvester with integrated ribboning will produce fresh ribbons ready for field stapling and fresh degumming at much less cost than the conventional hand stripping and scraping.
3. Portable ribboning machine should be provided to produce fresh ribbons from fresh stalks.
4. Fresh ribbons can be degummed after stapling to uniform length from 3 inches to 8 inches.
5. Partial degumming of fresh stalks with dilute 0.1% lactic acid for one hour in a rotary digester will facilitate subsequent decortication by simple drying and roller crushing.
6. The crude fiber staple produced from the above acid cooking can be degummed in two stages. A first stage degumming can be made with 1% caustic soda, 0.5% sodium sulfite and 0.2% sodium hexametaphosphate for ½ hour at 3 kg/cm^2. A second stage can be followed after acid washing with 0.2% hydrochloric acid at room temperature for 10 minute. The second stage consists of soaping for ½ hour at 1.5 kg/cm^2 in a solution containing 1% soap, 0.1% sodium hexametaphosphate and 0.2% teaseed oil.
7. Degumming of fresh ribbons may choose ammonia process, which involves cooking the cut ribbons with 1% ammonium hydroxide solution and 1% sodium sulfite for one hour at 3 kg/cm^2. The degummed fiber should have acid washing with 0.2% hydrochloric acid for 10 minutes at room temperature. The washed fiber is further treated in a soap solution consisting of 1% soap, 0.1% sodium hexametaphosphate and 0.2% teaseed oil for ½ hour at 1.5 kg/cm^2. The waste liquor from the two stages has fertilizer value and can be used in farm irrigation.

Immediate Objectives

1. The present 2-stage alkali degumming process cam be modified by first cutting the crude fiber into staple of 3-8 inches depending on the spinning system to be followed. Long staple may fit the existing long fiber system to make combed tops. Short staple would fit cotton system with various fiber blends.
2. Degumming the cut staple will facilitate subsequent mechanical washing without beating and suit continuous bleaching as usually practiced in ramie mills.
3. A modified 2-stage caustic degumming process was tested. This consists of degumming with 1% caustic soda, 0.5% sodium sulfite and 0.1% sodium hexametaphosphate for ½ hour under 2.8 kg/cm^2. After washing, a second stage degumming was followed in a solution of 1% tallow soap, 0.1% sodium metaphosphate and 0.2% vegetable teaseed oil for ½ hour at 1.5 kg/cm^2. The degummed fiber was bleached with 0.5% hydrogen peroxide and 1% sodium silicate for 30 minutes at 80°C. The bleached fiber was washed with 0.2% acetic acid for 10 minutes at room temperature. A final soaking in an oil emulsion containing 1% emulsified teaseed oil and 0.1% sodium hexametaphosphate was made in 15 minutes at 60°C. The test showed a yield of 73.3% with residual gum 1.95%, tensile strength 4.61 g/d, fiber fineness N 1662. The fiber quality appears good with high yield.

II. PROJECT ACTIVITIES

Work plan with schedules was drafted with HRTRI in Changsha. Expert activities were limited to laboratory tests and consulting seminars of various groups. Seven degumming tests were made at HRTRI laboratory with result recorded in the HRTRI report in Chinese on Oct. 12, 1986.

Five seminars were held with the following groups;

a) technical staff of HRTRI in Siangdan on Sept. 29, 1986
b) senior staff of HRTRI and four ramie mills in Changsha, on Oct. 4, 1986
c) staff of Bast Fiber Crop Research Institute in Yuankiang on Oct. 7, 1986
d) members of four provincial organizations in Changsha and agriculture authorities related to science, technology and economic development.

The seminar was sponosored by Prof. Kanyo Nieh of Chemical Industry Bureau and Mr. Ho of the Provincial Library and precided by Prof. C.M. Yin, Deputy Chairman of Hunan Provincial Political Consultation Council on Oct. 11, 1986

e) Professors and staff of Beijing Agricultural Engineering University, Beijing on Oct 20, 1986

The following three technical pamphlets on ramie degumming and related operations were distributed to HRTRI, RRI and Agricultural Engineering University for their reference:

a) Ramie -- Boehmeria Nivea: Decortication & Degumming, by Dr. Chien Chu, Ramie Consultant, September 1986
b) Ramie -- Boehmeria Nives, a Miraculous and TantalizingFiber: Plantation Cultivation & Harvesting by Dr. Chien Chu, Ramie Consultant, September 1986
c) Ramie -- Boehmeria Nivea: A possible New Pernnial Pasture and Forage Crop, by Dr. Chien Chu, Ramie Consultant, September 1986

Mr. Kanyo Nieh, noted consultant of Hunan textile industry has intention of editing a book on ramie technology. He has been active in participating most seminars and contributed his views.

A visit to Ramie Research Institute of Hunan Agriculture College was made on Oct. 12, 1986. Prof. T.D. Lee, Director of RRI made a briefing with his staff upon my visit. He has a comprehensive plan of organizing an international ramie symposium in Changsha by 1988. The Institute has done very extensive research on ramie agronomy.

III. NEW TECHNOLOGY

1. Modernization of fiber preparation and fiber grading

Technical advice on in-line degumming of fresh ramie stalks and ribbons was made at the laboratory of HRTRI during Sept. 23-28, 1986. Traditional manual stripping and scraping green ramie stalks are extremely labor intensive and uneconomical. Laboratory test at HRTRI showed cooking fresh stalks with 0.1% lactic acid for 1½ hour at 2.8 kg/cm^2 can liberate

the crude ribbons. In a rotating cylindrical digester, the ribbons can be separated from the woody core by spray washing.

A stapling machine can cut the graded fresh ribbons into three parts. The butt ends about 1½ inch should be removed. The lower one third part of the ribbons has coarser fiber than that of the upper two third part of the ribbons. Thus two grades of crude fiber can be prepared to suit subsequent processing of the crude fiber into coarse yarn or fine yarn separately. The waste butt ends can be processed into coarse yarn to make fish net.

The graded crude ribbons can be further stapled to desired length of 3 to 8 inches. This stapled ribbons can be baled for degumming in a textile mill.

2. Field preparation of fresh ribbon staple and its degumming.

Commercial ribboner machine for kenaf and jute can serve as well for ramie stalks. It can produce about 50-100 kg ramie ribbons per hour on dry basis. The fresh ribbons produced can be stapled immediately to 3-8 inches. The stapled ribbons are ready for fresh degumming by an ammonium process so that the waste degumming liquor can be returned to the ramie farm through an irrigation system.

3. Ammonium degumming process for fresh ribbons

A 2-stage degumming process for fresh ribbons is proposed. The first stage has a cooking liquor containing 1% ammonium hydroxide, 1% sodium sulfite and 0.1% sodium hexametaphosphate for one hour at 3kg/cm^2. A stainless steel rotary digester and a screw press can serve the purpose of cooking and washing without beating, which may damage the fiber. An acid washing should be made with 0.2% hydrochloric acid for 10 minutes at room temperature. The washed fiber can be further degummed for ½ hour at 1.5 kg/cm^2 in a soap solution containing 1% soap, 0.2% teaseed oil and 0.1% sodium hexametaphosphate.

A 3-stage peroxide batch bleaching is proposed as follows:

a) Acid washing with 0.2% hydrochloric acid for 10 minutes at room temperature.
b) Peroxide bleaching with 0.5% hydrogen peroxide, and 1% sodium silicate for ½ hour at 80-90°C.
c) Acid washing with 0.2% acetic acid for 10 minutes at room temperature.

A final oiling and softening with a solution containing 0.2% teaseed oil emulsion and 0.1% sodium hexametaphosphate for 15 minutes at 60°C should be made before drying. The bleached fiber yield is expected to exceed 75% on the weight of dry crude fiber staple with residual gum below 6% and tensile strength in the order of 4-5 g/d.

4. Improvement of degumming of dry crude fiber (China grass)

The existing two-stage caustic soda degumming process encounters extensive washing and beating of fiber after degumming the fiber in its natural full length. The improvement emphasizes stapling the crude fiber to desired length before degumming in two-stage, followed by peroxide bleaching. The first stage of degumming was cooking stapled fiber of 3 inch in a solution containing 1% caustic soda, 0.5% sodium sulfite and 0.1% sodium hexametaphosphate for ½ hour under 2.8 kg/cm^2. Then a second stage degumming was made with 1% soap, 0.2% teaseed oil and 0.1% sodium hexametaphosphate for ½ hour at 1.5 kg/cm^2. The degummed fiber was bleached with 0.5% hydrogen peroxide and 1% sodium silicate for ½ hour at 80°C. The bleached fiber was washed in 0.2% acetic acid for 10 minutes at room temperature. A final soaking of the bleached fiber in 0.3% teaseed oil emulsion with 0.1% sodium hexametaphosphate was made at 60°C for 15 minutes. The soaked fiber was centrifuged before drying in a dryer.

The above test showed a fiber yield of 73.3%, residual gum of 1.95%, tensile strength 4.6 g/d and fineness 1662 N. The brightness of the bleached fiber was good. Further laboratory tests should be mode to confirm the reliability of the result.

IV. FURTHER TECHNICAL ASSISTANCE

1. Further technical assistance in subsequent missions is envisaged in machanical harvesting and ribboning of fresh ramie stalks.
2. Mill test of the 2-stage caustic soda and soap degumming process after more laboratory tests on final result and fiber quality.
3. Experiment on bio-chemical degumming process in cooperation with Ramie Research Institute of Hunan Agriculture College.
4. Experiment on inproved chemical degumming process to suit existing degumming facilities in ramie mills.

V. FINDINGS

1. Ramie has been a neglected field in research and development. Rationalization of ramie degumming and fiber preparation on a long range plan calls for agricultural coordination in modern ramie cultivation on plantation scale instead of small plots, which make mechanization in harvesting and ribboning difficult.
2. With in-line degumming of fresh ramie at the plantation, degumming chemicals containing nitrogen and phosphorus can be applied so that the waste liquor from the degumming plant can be returned to the ramie field as fertilizer through an irrigation system.
3. The high cost of production of crude fiber by manual stripping and scraping can be eliminated by improved field process featuring acid cooking of fresh stalks with 0.1% lactic acid for one hour at 3 kg/cm^2 pressure in a rotary cylinder. The cooked stalks are washed and pressed to remove waste liquor and dried. The dried stalks are lined all on butt ends so that a rotary saw can cut off the butt ends and the rest part is crushed in a series of corrugated rolls with a turbine beater at the delivery end to separate the woody shives from the fiber ribbons.
4. A portable ribboner should be developed to produce fresh ribbons for immediate stapling and degumming.
5. A stationary ramie decorticator with washing attachment can be installed to serve a large plantation. The decorticated and washed fiber should be stapled and degummed in the fresh state.

6. A visit to Bast Fiber Crops Research Institute showed possible biological degumming for ramie. A 2-stage process for ramie is proposed. The biological degumming can reduce the residual gum to 12 percent. Then a chemical degumming can be followed with a solution containing 1% soap, 0.2% teaseed oil and 0.1% sodium hexametaphosphate for ½ hour at 1.5 kg/cm^2 pressure. The degummed fiber from the 2-stage process usually has very light color and bleaching is optional.
7. The above proposed biological degumming would suit best for stapled fresh ramie staple and should be carried out in ramie farms so that any waste effluents can be utilized in ramie irrigation.
8. Production of degummed fiber through mechanical fiber extraction and biological degumming can be developed as a specialized industry integrated with modern plantation. This will afford utilization of ramie byproducts such as forage feed and artificial board from ramie shive.
9. Cultivation and processing mushroom with ramie shive as compost and ramie degumming liquor as fertilizer can be exploited and will provide extensive rural employment. Dehydrated mushroom and canned mushroom have wide market. These byproducts can share the cost of degummed fiber.
10. Laboratory study on chemical degumming to suit existing degumming facilities in ramie mills. Some innovation could be made.

VI. ANNEXES

1. International staff

   Dr, Chien Chu, U.S.A. expert in ramie degumming, mission period was Sept. 16, 1986 to Oct. 20, 1986
2. Senior counterpart staff

   Mr. Kui Xu, director, Hunan Ramiw Textile Research Institute, Xiang Tan, Hunan

   Mr. C.X. Xiang, Chief engineer, HRTRI

   Mr. H. C. Ho, senior engineer, HRTRI

   Mr. C. L. Li, Deputy Section Chief of Science & Technology Dep., The Bureau of Textile Industry, Hunan

   Prof. T. D. Li, director, Ramie Research Institute, Hunan Agriculture College, Changsha

Prof. Kanyo Nieh, consultant, Hunan textile industry.

Ph.D. Zhu Xing, senior engineer, Department of Foreign Affairs, Ministry of Textile Industry

3. References

Chien Chu, "Revitalizing the Ramie Industry in the Philippines" Technical Report, March 1983, UNIDO

P. C. Das Gupta, K. Sen and S.K. Sen, "Degumming of Decorticated Ramie for Textile Purposes" Cellulose Chemical Technology 10, 1976

M. Petruszka "Ramie Fiber Production and Manufacturing" FAO, United Nations, Rome, 1977