0. EXECUTIVE SUMMARY

0.1 OPEN END ROTOR SPINNING-AN INTRODUCTION

0.1.1 The OERS technology was introduced, to the world, by Czechoslovakia, in sixties. This technology, successfully commercialised, through research and development, carried out, on a large scale, in Czechoslovakia, as well as, in many other countries, by the manufacturers of textile machines. OERS was, the first break-through, in the spinning technology, after, the conventional ring spinning, which has been commercially successful for a long time. Since then, the technology has been, further, developed and, as of today, about 22% of the spinning capacity, in the world, is on OERS.

0.1.2 The spinning components, of a typical OERS machine, comprise of a cleaning roller and a rotor. The material, cotton, synthetics or their blends, are fed to the machine, in the form of a drafted sliver. The cleaning roller, first, opens the material, in the form of sliver and, further, cleans and feeds it, to the rotor, via a feed tube. The rotor revolves at high speeds, ranging between 40,000 rpm to 1,00,000 rpm and the material, remains at the periphery of the rotor, to be drawn out, from the centre of the rotor, through a draw tube and a navel. The twist is imparted, at this stage, by rotation of the rotor. This twisted strand of fibres, in the shape of yarn, passes on to a winding unit, where it is wound, on, cones, or, cheeses, as desired.

0.1.3 The specifications of the cleaning roller, the rotor diameter and shape, varies, according, to, the type of fibres to be spun and the count. The count range, that can be spun on OERS machine, is from 1.5's to 42's. Coarser the count, larger the diameter of the rotor and vice-versa. The rotor speed can be, as high as 1,00,000 rpm, for fine counts. Such high speeds give, 2 to 10 times, more productivity, as compared to ring spinning technology. This factor and the elimination of speed frame and the winding process, makes OERS technology, comparatively, economical, than the ring spinning, for spinning of coarse counts.

0.1.4 Automated versions of OERS machines are available, on which ,the operations, like, mending an end break, cleaning of rotor and changing of full package, are carried out automatically. The OERS yarn shows, greater short term evenness, by about 10%, but lower tensile strength, by about 15-20%, as compared to, the ring spun yarn. The open end spun yarns find wide applications in, woven and knitted apparel, furnishing fabrics, sheetings, etc.

0.2 STRUCTURE OF INDUSTRY AND THE STATE OF THE ART

0.2.1 The OERS machine manufacturing commenced, in India, only in 1983. The following, three companies, have been licensed, to manufacture these machines.

MANUFACTURERS	LICENSED CAPACITY NO.OF MACHINES/YR
a) The Lakshmi Machine Works Ltd.	150
b) Star Industrial & Textile Enterprise Ltd.	100
c) Padmatex Engineering Ltd.	50
Total	300

The Lakshmi Machine Works Ltd. (LMW), manufactures OERS machines, in collaboration with Rieter Machine Works Ltd., Switzerland, and the STAR Industrial and Textile Enterprises Ltd. (STAR), manufactures the machines, based on indigenous technology. Though, Padmatex Engineering Ltd. possess, the licence to manufacture, such machines, in collaboration with Schlafhorst of W. Germany, they have not commenced the manufacture.

0.2.2 The LMW, a company of Lakshmi Group, has its plant at Coimbatore, Tamilnadu and manufactures the complete range of spinning machinery and pirn winders, whereas, other companises of the group manufacture, looms and other products. The STAR has its plant at Dombivali, Maharashtra and manufactures, a wide range of, textile machinery. Both the plants are equipped to manufacture various types of machines, as per the licensed capacity, but the production programme, for the entire range of machines is, so planned, that the production, of OERS machines, is restricted to, about ,48 machines per year, by each. Hence, the actual installed capacity can be said to be about 100 machines per year for the entire industry. LMW's standard machine contains 168 rotors, whereas, the STAR machine comprises of 144 rotors. Hence, the installed capacity is 8064 and 6912 rotors, respectively.

0.2.3 The STAR, first, introduced their OERS machine, in 1983 and till date, it has manufactured only 9 machines. Their, overall, turnover through this product, has been, in the region of, Rs. 96 lakh. The operation of STAR group of Industry has met a set back, since 1987, due to depeleted financial status of the company. The company hopes to revive its operation, in the near future.

0.2.4 The LMW, first, displayed their OERS machine, at the India ITME-84, the textile machinery exhibition, held in Bombay, in 1984 and since then, till Dec. 1988, they have sold 110 OERS machines. The total sales turnover of LMW, for OERS machines, has been, in the region of, Rs. 1760 lakh.

0.2.5 The plant of STAR, for manufacturing OERS machines, is equipped with a machine shop and assembly line; the casting, die-casting and fabrication work are given out, on contract, to ancillaries.

On the other hand, the plant of LMW, is well equipped with a foundry, modern machine shop and an assembly line. The machine shop has installation of CNC and sophisticated, speciality, machine tools.

0.2.6 STAR developed and designed their model of OERS machine, indigenously, through their own developmental efforts, whereas, LMW entered into a collaboration agreement with Rieters of Switzerland. Rieters did not develop their rotors and have been equipping their machines with Czechoslovakian rotors, of Elitex make. Thus, know-how, available with LMW, has been limited, to manufacture of machine, except, spin boxes. As such the spin box, comprising of critical parts, like, rotors, cleaning rollers, etc., has to be imported, as the know-how, for production of these parts, is not available with the Indian manufacturer.

0.3 STATE OF ART SCENE (INTERNATIONAL)

0.3.1 Manufacture of OERS machines is being carried out, world wide, since 1967, when first commercial machine was introduced by Czechoslovakia. There are, about, 12 companies manufacturing these machines and they are located in the Europe and Japan. The Elitex, (Czechoslovakia) Schubert and Salzer (W.Germany), which have been, recently, taken over by Rieters (Switzerland) and Schlafhorst (W.Germany), are the leaders in manufacture of latest versions of OERS machines. Significant developments have taken place, since the first introduction of these machines. These developments are :

a) High rotor speed, upto 1,00,000 rpm.

b) Automatic operations for mending an end break, cleaning of rotor and changing of full packages.

c) Supply and delivery of packages of larger size.

d) Attachements for, computerised production information, supply of starters, storage of packages, etc., are also available.

e) Electronic, yarn evenness control, for better uniformity of yarn.

These are the major developments, which have taken place on OERS machines, lately and most of the international companies have, already, brought out, their products in the market, with such features.

0.4 COMPETING TECHNOLOGIES

0.4.1 Ring spinning is, the conventional technology, in vogue, for spinning of yarn from, cotton, wool, spun silk, synthetic fibres and their blends, etc. With the threat from OERS technology, the ring spinning technology has, also advanced, considerably, during the last decade. Spindle speeds have gone upto20,000 rpm. Automation has been introduced for doffing of full bobbins. The latest

development is, the linking of machines with, winding machines, in which, the full bobbins, doffed by the autodoffer, are directly fed to the cone winding machine, attached at the end of the ring frame. Automatic creeling of roving bobbins and roving feed stop motion, have, also, been introduced. These developments have brought about a considerable degree of advancement in the ring spinning technology. However, these developments could not be a threat to OERS, due to limitation in, increase of speed of Ring Spinning.

0.4.2 The friction spinning system, though introduced a long time back, has not been a commercial success. Though, the system can be used for spinning yarns, from, cotton, man-made fibre and blends, it is limited to medium count range only. Finer counts cannot be spun on this system, due to high end breakage rate and formation of neps in the yarn, accompanied by low tensile strength. Friction spinning, however, proves, economical due to, its high speed, omission of speed frame and rewinding process and the yarns being very even, fabrics spun from these, show, a relatively, soft handle.

0.4.3 The latest addition, to the spinning technology, is the Air jet spinning technology, which was introduced, in the year 1980. The machine spins, cotton, synthetics, and their blends, in the count range of, 10s to 80s. The productivity for fine counts is, about, 15 to 20 times, higher than the ring spinning. The jet spin yarns are more uniform, but weaker in strength, than ring spun yarn, but stronger than the open-end spun yarn. Yarn cleaners are provided at each spinning unit, which give very uniform yarn. Fully automated version of air jet machines is available, with an auto-doffer, for change of full packages and autopiecer for mending end breaks. The machines can be attached with computerised production information system and package transfer system, for storing the full packages. The jet spun yarn finds, only limited applications, due to harsh feel and is found to be, more suitable, for spinning, synthetic fibres and thier blends with cotton.

0.4.4 Thus, when comparing the OERS technology, with other contemporary spinning technologies, the, following, limitations of, OERS machines and Open-End Rotor Spun Yarns, are brought out:

a) machines cap spin economically, in the count range of, 1.5s to about 40's, only,

b) lower tensile strenght of yarn, by 15-20%, than ring spun yarns,

c) higher twist in yarn, by about 10-15%, because of which,there is a limitation in use of OERS yarn, in fabrics, requiring higher absorbancy of water, like, towelling and rough feel of OERS yarn, which results in production of, comparatively, harsher grey fabrics, which require different treatment in finishing,

d) limitations in use of Open-End Rotor Spun Yarn, for industrial and other such end uses, due to lower tensile strength.

e) difficulty in dyeing OERS yarn; to dark shades because of their open structure.

f) higher power consumption at spinning stage vis-a-vis ring spinning.

g) lack of versatility in handling various count ranges by a given configuration of machines. Rotor diameter and material of construction, require, change, as a result of change in count range and fibre/blend, to be spun.

h) high capital cost of open-end spinning machines, particularly, state of the art machines, imported from general currency areas.

0.5 TECHNOLOGY ABSORPTION EFFORTS

0.5.1 The R&D activities, on OERS, carried out by various research laboratories, in the country, like, ATIRA, BTRA, SITRA, etc., relate to the optimum use of the raw material, machinery and man power. It is ony the R&D wings, of existing two machinery manufacturers, who have worked, in a limited way, on the development and design of OERS.

0.5.2 STAR conceived the development programme of OERS machines, in 1977 and developed a 12 Rotor prototype machine, in 1980, without any assistance from foreign manufacturers or laboratories. In 1983, STAR introudced their commercial model, equipped with indigenous electromagnetic clutch, ball bearings, micro switches, motors and panels, etc., but with, imported rotors, opening rollers, doffing tubes, tension pulleys with tangential belts and power grip belts, etc.

0.5.3 LMW has been, consistently, working on the improvement in design of various components and incorporating improved technologies in their earlier model M1/1, manufactured in 1984, in collaboration with Rieter of Switzerland. In their new model M1/2, LMW has been able to increase the rotor speed, from 60,000 rpm to 80,000 rpm and accommodate 192 rotors per machine, instead of 168. Further, LMW have also successfully developed, three stage suction fan, electronic brake system for opening roller, pneumatically operated rotor cleaning system, traversing unit for cones, etc., for their models of OERS machines.

0.5.4 In a span of 5 years, the indigenous OERS machinery manufacturing industry has manufactured and sold 119 machines, valued at Rs. 1856 lakhs. Though, the first OERS machine was installed, in Indian textile mills, in 1972, which was of imported make, the demand of these machines was not significant, till about 1984-85.

0.6 INTERACTION WITH USER INDUSTRY

0.6.1 As on today there are about 340 OERS machines, comprising of, about, 65,000 rotors, installed in, over, 120 textile mills in the country. A survey carried out in the industry, reveals that OERS technology, has been well received and stabilised in the user industry.

0.7 ECONOMICS OF OERS TECHNOLOGY

0.7.1 Even though, the open-end rotor spinning gives much higher spinning speeds and consequently, much higher output, as compared to ring spinning, it is much less versatile as compared to ring spinning, which can spin any count-range, fibre blend, fibre length and fineness. As already mentioned, specification of the cleaning roller, rotor diameter and shape vary according to the fibre and count spun. The spinning speed is, also, sensitive to the count spun, higher the count spun, the higher is spinning speed. Higher spinning speeds, adversely affect, the spinning stability, increase the twist loss and generally, affect the regularity of yarn. The effect of increased spinning speed, can be countered, to some extent, by increased fibre fineness. The fibre blends also have an effect on machine performance: titanium dioxide content of synthetic fibres increases abrasion of the cleaning roller and rotors, and therefore has to be countered by choice of suitable materials for rotor construction and coatings. Power consumption, at spinning stage, in open-end rotor spinning is high, as compared to ring spinning, but the absence of, a number of spinning preparatory and post spinning operations, compensate, to some extent ,this high power consumption, particularly for coarse counts. Also, open-end spining does not require winding operation, in post spinning section, as is the case with ring spinning. As a result of all these, the open-end spinning:

a) does not have the advantage, over ring spinning, over the entire range of counts, particurlarly, finer counts.

b) the configuration of open-end spinning machine does not remain same, for all fibres, and count ranges.

As a result of all these, the choice of spinning system, between ring and open-end rotor spinning systems has to be carefully made keeping in view the operating parameters, such as, fibre characteristics, counts to be spun, dyeing characteristics of fabrics and cost of inputs, like, power, labour capital, cost of machines,etc. Also, the configuration and speed range, of OERS machines, has to be carefully decided, keeping in view all these factors.

0.7.2 As compared to ring spinning, Indian OERS machines are economical to spin upto about 16's count, under local conditions, because of higher productivity and savings in, labour and power cost. Under Indian conditions, the OERS machines have been found suitable for spinning cotton (including wastes) and

not so suitable, for spinning synthetics and blends. The capital cost of OERS machines, particularly, state of the art machines, imported from general currency areas, which is extremely high, has inhibited adoption of OERS technology in India, where, the costs of textile labour is, still, quite low.

0.7.3 Mills, working on coarse counts, would find it attractive, to go in for OERS technology, while considering, replacement of old machinery or setting up a new venture.

0.8 PROJECTED DEMAND OF OERS

0.8.1 India, which has the largest installed spinning capacity, in the world, has, hardly, 0.8% capacity on OERS, against, 22%, overall, in the world, 64% in USSR and 66% in Hongkong. To meet the projected annual demand, of, about, 169 million kg, in coarse counts, India would need, an installed capacity of, 2.57 lakh rotors. The demand of rotors, for new machines and replacements, is projected at 62,000 rotors, per annum, by 2002 AD and offers, substantial scope, for taking up manufacturing, indigenously.

0.8.2 In India, nearly, 52% of international makes and 8% of Indian makes, of OERS machines, are installed in composite mills and the rest in the spinning mills. The real and much brighter prospects, for OERS machinery manufacturing industry, can only be there, if composite mills are, also, attracted to adopt this technology and for that, upgradation of technology, with selective automation, is a must.

0.9 TECHNOLOGY GAPS AND THRUST AREA

0.9.1 Indigenous OERS machines are, simple versions of such machines, with imported spin boxes, on which, operations, like, mending an end break, cleaning of rotors and changing of full packages, are carried out manually. International makes, of OERS machines, are versatile, with installation of, upto, 216 rotors per machine, for the count range, 1.5's to 42's, for cotton, as well as, synthetics; having, spinnable staple length upto 60 mm, working at rotor speed of 1,00,000 rpm and equipped with computerized production information system and electronic, yarn evenness control.

0.9.2 Due to lack of educational and organisational infrastructure for, textile machine design discipline and organised research and developmental efforts, the indigenous technology is very much handicapped. It is necessary to establish, educational infrastucture, for textile machinery design and development. It is also necessary that, R&D programmes, for development of state-of-the-art-textile machinery, including OERS, should be taken up, by textile machinery manufacturers. Institutional support, for such programmes also, needs to be developed, either, at existing R&D/educational institutes, or, by setting up new institutes.

0.9.3 The proposed institutes should concentrate, on design, engineering upgradation of the technology, with priority, on development of spin boxes, which are being, currently imported and selective automation of the machine, desired by local textile mills and required for exports.

0.9.4 Till indigenous technology is developed, which may take a long time, it will desirable to acquire the foreign technology for the latest OERS machine, by entering into collaboration with a, reputed, international manufacturer.

0.10 CONCLUSIONS

0.10.1 OERS spinning technology has a number of advantages, over the ring spinning technology, such as, increased spinning speed (2 to 10 times of the ring spinning speed), absence of spinning preparatory machines, like, speed frames, draw frames (in case of very coarse counts), etc., as well as, absence of certain, post spinning operations, like, cheese/ cone winding, etc., which are needed, in case of ring spinning.

0.10.2 Because of the absence of some, preparatory and post spinning operations, as well as high output per machine, OERS machines give a substantial, saving in labour cost.

0.10.3 State-of-the- art OERS machines are available with a high degree of automation, such as, auto doffing, automatic yarn piecing, automatic sliver can change, automatic yarn eveness control, automatic production and operating data recording, etc, as also, centralised computer control. Indigenous machines have speed upto 80,000 rpm, Also, they lack most of automation features and are, by and large, manually controlled.

0.10.4 OERS machinning give, a better regularity of yarn which has, better stretch charateristics and, therefore, better suited to weaving, on high-speed automated looms.

0.10.5 The limitation, of OERS machines, are : high power consumption, at spinning stage; lack of flexibility to take up various fibres/ blends and count ranges, with the same configuration of machines; slightly lower strength of OERS yarns, difficultly in dyeing yarn of dark shades etc.

0.10.6 The initial cost of OERS machines, in general and state-of-the-art OERS machines, imported from the general currency area, in particular, inhibits the use of OERS machines in India, where cost of textile labour is low and the financial health of the textile industry is, generally, not good.

0.10.7 The analysis shows that use of OERS machines, in India, is economical, upto, a count of 16s, in cotton, at existing level of the cost of, labour, power, interest rates and initial cost of machines, both, of OERS, and ring spinning.

0.10.8 Indigenous OERS machines are built with a heavy input content. The heart of the machines, the spin box, is imported from Czechoslovakia, as is the case with many international firms, manufacturing OERS machines. High import content increases the cost, of indigenous machine, because of the incidence of customs duties, even though, their cost is, much less, than imported machines.

0.10.9 It may be difficult to increase indigenisation, of critical imported parts, if the demand does not pick up, substantially, over present levels.

0.10.10 Even for the, limited, indigenous demand, the indigenous production level, does not seem to be adequate, the delivery period of indigenous machines is reported to be 3 years,. Also, imports, despite, high cost and duties, are substantial

0.10.11 Out of two units, given foreign collaborations, only, one has come into production. Nothing is known, about the collaboration, of M/S Padmatex with Schlafhorst. M/s. Star Textile have discontinued production of OERS machines, after a considerable R&D effort was spent on developing the same.

0.10.12 The manufacturing technlogoy, of OERS machine, can be, further, developed, indigenously, with the exception of, Rotors, Bearings, Opener Roller, Power Grip belts and Navels on yarn withdrawl tubes. The accuracy and superfinish given the tracks of, ball races of the bearings; raw material of the rotor; the dynamic balancing of the rotor; various finishes imparted to the rotor, for larger life; the accuracy of the groove geometry; diamond polishing on ceramic; are, perhaps, a little difficult, to achieve, by indigenous manufacturers, immediatly. The yarn withdrawl tube and the ceramic navel, can be manufactured indigenously, but the process to achieve uniformity of quality, on a large scale, is, perhaps, not available.

0.10.3 Because of the economic constraints, on applications of the OERS technology, which is limited to coarser counts in India, the machines have found limited applications in the textile industry. Hence, even though, the machines were first introduced in 1967, at the international level, its manufacturing in India commenced, only, in the year 1983. There are three companies, in the country, who have been licensed to manufacture these machines. However, only two campanies ventured to take up manufacturing of these, in India, and even after acquiring license to manufacture, as well as, foreign collaboration, the third company did not commence the manufacturing.

0.10.14 India, which has the, largest, installed spinning capacity, in the world, has, hardly, 0.8% capacity, on OERS, against, 22% overall in world, 64% in USSR and 66% in Hongkong. Indian textile mills industry has been slow in responding to the OERS technology, which has, however, lately picked-up. India offers, a substantial scope, for taking up manufacture of OERS machines, including, critical components.

0.10.15 There is a wide technology gap in the product specifications, in terms of, productivity and automation, between the Indian and international level of technology. One of the reasons attributed to this is, the more demand for such machine, from medium scale textile mills, who prefer low-priced machines. The efforts are being made, by the Indian manufacturers, to bridge the gap, to some extent.

0.10.16 Educational and R&D infrastructure, for machine design discipline, for textile industry, in India, needs to be developed. No attempts, have been made to absorb, the design know-why, acquired, by the way of foreign collaborations. The real constraint, in development of state of the art textile machinery, in India, is the lack of availability, of manpower, with experience in textile machinery design, institutional R&D support required for this kind of effort and, not so much, the manufacturing capability, for machines and their components.

0.10.17 Mainly, because of the technology gap, local OERS machine can not be sold, in the international market and hence, the export has been nominal and directed to developing countries, only. On the other hand, the import, of assembled machines, as well as, components, have been increasing, as spin boxes, for which no technical know-how is available, for manufacture, continue to be imported.

0.10.18 R&D activities, for development of technology and upgrading the product specifications, has been undertaken, in a very limited way, by the OERS machinery manufacturers, only. The other, research institutions and laboratories, have worked, only, on improving the operational performance of the machines. With the work done by various agencies, OERS equipment, installed in the country, indigenous, as well as, imported, is being utilised, at the optimum level, by the user industry.

0.10.19 Technology for same critical parts, of OERS machines, such as, rotors tangential belts, etc., is not available, in India.

0.10.20 Air Jet and friction spinning technologies are, also, making their presence felt, in developed countries, such as, U.S. However, they have certain, inherent, limitations in respect of yarn quality, because of which, their scope for adoption, in India, is limited.

0.11 RECOMMENDATIONS

Based on the observations, made during the study, it is recommended that the following measures, to absrob and upgrade, the OERS machine manufacturing technology,should be taken, giving priority in the following order.

0.11.1 As considerable savings are likely to be achieved, in the overall economy of spinning of coarse counts, on OERS machines, the textile mills industry

should be encouraged towards using these machines, on large scale. Such encouragement could comprise of, better availability of indigenously produced machines, lower import duties on the parts of the machine which cannot be indigenised in near future, so that, the cost of indigenous machine, can be reduced.

0.11.2 Design and development capability for textile machineries, in general and OERS machines in particular, should be created in the R&D institutions, in the field of textiles. If necessary, a new R&D institution should be created to have expertise in the area . Such an R&D institute should collaborate, actively, with the industry, in development of, state of art textile machinery. The institute may, also, have R&D cooperation, with international institutes or reputed textile machinery manufacturers, abroad.

0.11.3 Till, indigenous technology is developed, which may take long period, it is, also, be desirable to acquire the foreign technology, of the latest OERS machines, operating at international level by, entering into collaboration, with an international manufacturer. Production of the existing models could be continued, for supply to the medium scale textile mills, where as, the automated version of Indian OERS machines, should be developed to compete with, the large, scale imports of such machines and exports. The products, for local market, should have selective automation, to keep the price low, but to fullfil the requirements, of the composite textile mills and production of quality yarn for exports.

0.11.4 High degree of precision is required, in the manufacture and assembling of OERS machine, as these machines operate at very high speeds, continuously, for long periods. It is recommended that; the existing manufacturing facilities should be modernised, with installation of modern CNC and special purpose machine tools. Such machine tools, beside giving higher productivity, carry out the jobs with desired accuracy. Some such machines tools are, also, available indigenously.

0.11.5 Currently, as, only, one company is in operation, for manufacturing OERS machines, the other having had cut down its operations, due to depleted finances, it is recommended that, one more machinery manufacturer should undertake a project to produce these machines, in India, as it would introduce a fair competition, in the market and provide as *suo moto* control over the prices.

0.11.6 Educational infrastructure should be developed, for machine design discipline, in textile industry, to achieve self sufficiency in textile machine designing. It is a gap area, in terms of human resource development, as a result of which, the existing textile research institutions are, not able to venture into, design and development, of textile machinery.

Technology import, for manufacture of some critical parts, of rotor spinning machines, such as, the speed box, automation system, etc., is desirable, to increase the indigenous content of such machines.

0.11.7 Developments, in air jet and friction spinning technology, should be closely monitored, to have a constant review of these technologies, for possible adoption, in India, in future.