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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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17123

DP/ID/SER.A/1072
20 October 1988
ORIGINAL: ENGLISH

APPLICATION OF CAD/CAM TECHNIQUES IN THE SILK DYEING, PRINTING AND FINISHING INDUSTRY - PREPARATORY ASSISTANCE

US/CPR/88/010

CHINA

Technical report: Review of current level of technology in the silk-processing industry in China, preconditions for introducing CAD/CAM techniques and socio-economic effects of applying such techniques in the silk industry.*

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 A.S. Bhalla, economist and
R. Hirschler, silk dyeing, printing and finishing specialist

Backstopping officer: A. Eräneva, Agro-based Industries Branch

United Nations Industrial Development Organization
Vienna

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* This document has not been edited.

V.88-30186

APPLICATION OF CAD/CAM TECHNIQUES IN DYEING, PRINTING AND FINISHING IN THE CHINESE SILK INDUSTRY

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INTRODUCTION

The successful application of CAD/CAM techniques in the aerospace and automotive industries in the late 1960s and early 1970s, through the use of maninframe computers, has led to innovative approaches towards its wider application. One such approach was the development of a microcomputer-based system offered by the pioneers of the CAD/CAM industry.

The introduction of minicomputer-based technology has been considered particularly suited for industries where modern technology could be applied without totally replacing existing technology. Such blending of advanced technology was comprehensively discussed in UNCSTD-sponsored workshops held in Los Baños, the Philippines (1983), Tokyo (1984) and in San Miniato, Italy (1985), where the Italian experience in silk industry was thoroughly reviewed.

As a follow-up to the San Miniato workshop the UNCSTD discussed with the Chinese authorities a possible study on the enhancement of China's silk industry through computerized technology, in particular through the introduction of CAD/CAM techniques in dyeing, printing and finishing.

China is the world's largest producer of textiles and its silk export accounts for over three-fourths of the world's total volume of silk trade. Most of the exported silk is in the form of silk yarn and grey, i.e. unfinished, silk cloth. Both the volume of export and the earnings from it could be greatly increased by increasing the value of the product through further processing into finished silk fabrics.
Advanced technologies, in particular the latest CAD/CAM techniques,

provide the necessary means. They lend themselves well to textile processing in general and their application in silk processing is particularly appropriate in view of the high-value raw material used.

Owing to the silk processing industry's backward linkage with the rural economy, in particular in cocoon production, the enhancement of the capacity of China's silk industry through CAD/CAM techniques would contribute to the implementation of China's SPARKS programme, initiated by the State Commission for Science and Technology to promote rural economic development.

Following the consultations held by UNCSTD and UNIDO with the Italian Government during the latter part of 1987 and early 1988, it was agreed that the Italian government would finance a preparatory mission to China through its contribution to the UNIDO-administered United Nations Industrial Development Fund, to:

* review the current level of technology in the silk-processing industry in China and to establish the preconditions for introducing CAD/CAM techniques in the silk dyeing, printing and finishing sub-sectors;

* assess the socio-economic effects of applying such techniques in the silk industry, with particular reference to linkages between rural and urban areas;

* determine the most appropriate mode and route for introducing advanced technologies, in particular CAD/CAM techniques in silk dyeing, printing and finishing in China and quantify the external technical assistance required to accomplish the task.

The members of the Mission were:

Dr. A.S. Bhalla, Economist (Technology Transfer),

Dr. R. Hirschler, Silk Dyeing, Printing and Finishing Specialist,

Mr. A. Padang, UNCSTD staff member,

Mr A. Eraneva, UNIDO staff member,

Mr S. Taglienti, Representative of the Italian Government.

The Mission team arrived in Beijing on 1 September and departed on 17 September. It had extensive discussions with the Chinese authorities concerned (See Annex I) and visited the silk factories selected by the Chinese authorities as the most appropriate counterpart production units in Shanghai and Hangzhou (see Annex IV).

The findings and conclusions of the Mission are set out in Chapter I below.

CHAPTER I

SUMMARY AND CONCLUSIONS

Over the years the Chinese silk industry has grown in importance so much so that at present China is the largest producer of silk and silk products in the world. Over 600,000 hectares of land are under cocoon production giving livelihood to several million farmers. Over 800 enterprises in the silk industry give employment to 650,000 people. The output of silk industry including cocoon production has expanded considerably during 1980-87. The Chinese government is very keen to increase the share of processed silk exports. To attain this objective, China faces a big task of market research and prospection to identify export potential of its silk products in high-couturier market, and low price end of the market.

Rural-Urban Linkages

Three types of linkages of the Chinese silk industry are considered: output, consumption and employment linkages. At present, rural-urban linkages of the industry are quite limited. The government policy of decentralisation of decision-amking to individual enterprises under the urban reforms has reduced the scope of sub-contracting between large and small enterprises. Indeed, it has led to growing competition between rural silk reeling and weaving factories and the state-owned factories.

The backward linkages of the silk industry to agriculture and input-supplying cocoon industry are also weak because of the relatively low price for silk cocoons compared to that for other cash crops like tea. This discourages farmers from investing in silk cocoon production. The rapid growth of rural industry is further shifting investment away from agriculture in general.

The current output of silk cocoons is well below the growing demand of the silk industry for raw material. Apart from the domestic demand for silk and silk products (which is steadily growing particularly in the urban areas) potential also exists for expanding export markets. However, this potential can be exploited only if the supply bottlenecks in the silk industry, viz. lack of raw material and energy supplies, non-availability of good-quality local dyestuffs and old low-productivity technology, can be overcome.

Socioeconomic Effects of CAD/CAM Techniques

At present the Chinese silk industry uses mainly manual labour-intensive technology in the dyeing and printing processes. While some automation has been in place for some time under a programme of technological modernisation, more advanced imported equipment is also being introduced. Some use of computer-based technology is also made in management and cost accounting and to a lesser extent, in the manufacture of silk and silk products. At the prevailing factor prices in China (low labour costs and high cost of capital and foreign exchange) and lack of adequate training facilities in computer technology, a widespread use of CAD/CAM techniques which are very new to textiles and have to be imported, would not appear to be justified on economic and social grounds. Socioeconomic cost-benefit analyses need to be done before importing expensive hardware.

Three important socioeconomic factors in the application of CAD/CAM techniques to Chinese silk industry need to be considered. These are: i) employment impact, ii) skill and training implications and, iii) export prospects through increased competitiveness resulting from increase in quality and greater flexibility in responding to orders from foreign markets.

A selective use of CAD/CAM techniques for the export segment of the market can be justified to meet the objective of raising exports of high-quality silk and silk fabrics. But the Chinese silk industry offers employment to a large number of people. The social cost of labour displacement likely to be caused by the use of high technology needs to be balanced against the expected benefits in terms of foreign exchange earnings from increased exports of silk products. In principle, positive employment impact of the use of CAD/CAM through an increase in Chinese silk exports is possible if a certain number of conditions noted above are fulfilled.

In the light of the above, the following conclusions can be drawn. First, initially the use of CAD/CAM should be confined mainly to production for the export market. Secondly, planning and management of allocation of scarce raw material (silk cocoons) between village enterprises and state-owned factories producing for the export market would be necessary.

Thirdly, measures would need to be taken to promote rural linkages of the silk industry by offering economic incentives to farmers to produce more silk cocoons. Fourthly, measures would be needed to promote the diffusion of CAD/CAM within the Chinese silk industry. Fifthly, studies may be undertaken on the ways and means of promoting technological linkages of the silk industry to the rural sector, as for example, is intended by the SPARKS programme. Finally, cost-benefit analyses on the application of this technology on a wider basis should be undertaken with the assistance of institutions dealing with the macroeconomic issues in the country, such as the Institute of Industrial Economics of the Chinese Academy of Social Sciences.

State of Technology in the Silk Factories Visited

A brief survey (three factories selected by the Chinese authorities) was made to assess the most appropriate mode and route for introducing CAD/CAM techniques in the silk dyeing, printing and finishing industry in China. In particular, the following areas of computer application have been considered: (1) computer-aided design; (2) automatic manufacturing of printing screens; (3) computerised colour matching; (4) automated colour kitchens; (5) process control of dyeing, printing and finishing machines; (6) quality control; (7) production planning/control and management information systems.

The production machines in the Chinese factories visited range from the traditional dyeing frames and hand-printing tables to microprocessor-controlled dyeing and printing machines, computerised colour matching systems and even prototype CAD systems. The quality of printed silk in these factories also varies from medium to high; their best export quality is in the upper region of the average quality in developed countries, but is somewhat below the top end of the market.

Mode and Route for Introducing High Technology

The objective of introducing CAD/CAM techniques in the silk dyeing and printing industry in China would be to bridge the gap between the top end of the market and the present possibilities of the industry in the following areas: (a) making more fashionable and sophisticated designs; (b) improving the technical quality of printing; (c) improving the quality of the silk fabric (handle, drape) and (d) reduce response time (confirmation of customer's order and delivery).

The rate of progress in the introduction of CAD/CAM techniques in the silk industry in China is not as high as desired, primarily due to financial constraints and lack of technical information. Nevertheless, in the light of the factory visits in Shanghai and Hangzhou, and the discussions throughout the Mission it is clear that CAD/CAM applications are technically and socially feasible in the Chinese silk industry. External assistance is needed both in terms of equipment and expertise.

The best overall impact/investment ratio is to be expected from computer-aided design (CAD), primarily because the efficiency of this technique is practically independent of the technical level of subsequent processes. It is also this field of application, where results can be achieved in a relatively short time. As a first stage a CAD system with design-editing and colour separation capabilities, and a full colour printer to provide fast response to customers' demands may be aimed at, at a current price-level of around US $3-400,000. External assistance may be provided in system selection, start-up and subsequent training.

In addition to CAD, expertise and training should cover the following areas:

- colour measurement and colour matching;
- dyehouse automation (computer-controlled weighing and application of process controllers);
- computer applications in quality control.

Computer-controlled weighing of dyestuffs improves the repeatability of the dyeing/printing process, and thus reduces costs and improves quality of the final products. This can be introduced without investing in a fully automated colour kitchen for which the preconditions are not yet met in the Chinese silk industry. The relatively small capital investment vs. significant results to be expected justify further consideration of this technique.

CHAPTER II

APPLICATION OF COMPUTERS IN SILK DYEING, PRINTING AND FINISHING

The application of computers in the textile industry started more than 20 years ago, colour matching being the first technique to be introduced on a commercial scale. In the 1970s the use of microprocessor-based process controllers has started as well as the application of general purpose computers in different fields. The application of computer-aided design - although widely used in engineering for over a decade - is relatively new in the textile industry: most of the manufacturers introduced their up-to-date systems based on powerful mini- or microcomputers only in 1987 at the International Textile Machinery Exhibition.

This Chapter describes briefly the main fields where computer techniques may be applied in silk dyeing, printing and finishing, indicating the state-of-the art as practised in the most developed countries.

1. Computer-aided design (CAD)

This is CAD in the original sense, i.e. the use of computer graphics for: (a) the generation of patterns on a colour monitor by the artist; (b) "reading in" patterns or motifs via camera or scanner; (c) making a hard copy of the generated design by full colour printer either on paper or on textile; (d) making colour separated transparencies (negative or positives) for screen making.

Precondition

- Total familiarity with the system.

Advantages

- Directly applicable, practically independent of subsequent processes.
- Shortens response time from several weeks or 1-2 months to a few hours for customer's approval of the design (by showing the customer on paper or even silk, the full colour print produced by the computer) and to 1-2 weeks for delivery (where the actual production time is shortened by making colour-separated transparencies on the CAD system).

Limitations

- Some designs may not be processed by CAD system.

Capital cost

- About US $200-300,00 for basic system;
- up to US $2 million for very advanced system.

Diffusion

The first systems for making colour separations (transparencies) were marketed in the early 1970s. The new generation based on advanced computers was introduced in 1987 at the International Textile Machinery Exhibition [ITME] in Paris. In recent months some systems of this new generation have been purchased by companies in the printing industry in Europe and the United States.

2. Automatic manufacturing of printing screens

This can be considered as the first step into CAM, where the CAD design work station provides information (either on-line or through magnetic or optical media) for the computer-aided manufacturing of flat or rotary printing screens, e.g. by laser engraving.

Preconditions

- Availability of CAD system.
- Adequate technical conditions for laser engraver.

Advantages

- Further reduction in delivery time;
- Quality improvement, practically no need for screen corrections;
- Certain designs may be produced which are not possible by conventional screen making.

Capital Cost

- About US $700,000 to 1 million.

Diffusion

For flat screens the technique has been available for several years, for rotary screens it became available only in 1987.
Some big printing mills in developed countries already apply this technique.

3. Colour matching: colour measurement and recipe prediction (CCM)

In CCM we have a colour-measuring instrument (spectrophotometer) in on-line connection with a computer. The colour measurement data can be used for quality control of incoming dyestuffs as well as for outoging textiles (pass/fail decisions: is the colour of the product near enough to target?); the system is also capable of recipe prediction: (how much of which dyes should be used to achieve the desired colour?) The computer is also quite often used for dyestuff management (stock control) and controlled weighing (as an alternative to separate computer in colour kitchen).

Preconditions

- Well-equipped laboratory for the preparation of highly reproducible calibration dyeings and prints;
- Adequate control of production processes (by conventional methods or through automation);
- Adequate control of the quality of incoming dye-stuffs, chemicals and substrates used;
- Full understanding of not only the operation of the CCM system, but also that of the colour science (and its practical implications) behind CCM.

Advantages

- Significant reduction of dyestuff costs through recipe optimisation;
- Better quality through instrumental control;
- Reduction of dyestuff stocks.

Limitations

- Some colours may not be matched by CCM (only 1-2%);
- Small areas of printed samples (in any direction smaller than 1-2 mm) cannot be measured;
- Limited accuracy of first predictions (recipes) for flourescent colours and for fibre blends.

Capital cost

- About US $40,000 to 120,000 depending on configuration.

Diffusion

CCM has been widely used for the last 20 years in all developed countries. It is the most common industrial application of computers in textile dyeing and printing. Already there are quite a few systems operating in developing countries (including China), but in many cases the systems are not fully utilised due to lack of adequate training (see Preconditions).

4. Automated colour kitchen - controlled weighing

The computer-controlled weighing of dyestuffs and print-pastes, and the automatic dispensing of dye-liquors and print-pastes ensures that each dyeing/printing lot is produced exactly according to the predetermined recipe. Dyestuff inventory can be continuously updated by the weighed/dispensed quantity; recipes and production instructions can be printed for each lot by the computer.

Preconditions

- Central colour kitchen for dye-liquor resp. print-paste dispensing needs large enough space;
- Dyeing and printing processes in the factory must be analysed in full detail and streamlined to the necessary extent prior to automation.

Advantages

- Significant increase in repeatability;
- Advanced information system for dyestuff management (stock control, minimum level warning, pricing);
- Minor savings in manpower.

Limitations

- For controlled weighing none, but incoming dyestuff quality must be consistent;

Capital cost

- About US $10-20,000 for controlled weighing and dye-stuff inventory;
- About US $2-300,000 for total colour kitchen with dispensing.

Diffusion

Application of this technique can be found in various forms and configurations, from the simplest to the most sophisticated, in a great number of dye-houses and printing mills in developed countries.

5. Process control

Practically every dyeing/printing/finishing machine can be equipped with [microprocessor-based] process controllers of various degrees of sophistication: regulation of fixed-value process parameters (speed, temperature, pressure, etc.); programming of process- or operation-sequences; on-line data-acquisition; programmed control of complex systems.

Preconditions

- Production machine to be automated must be either brand new or at least in faultless condition;
- Sufficient steam, water and power supply;
- Dyeing and printing processes (technologies) must be analysed in full detail, and streamlined to the necessary extent prior to automation.

Advantages

- Better quality through higher reproducibility;
- In many cases, increase in productivity;
- Savings in manpower, energy and materials;
- Possibility of eventual connection with central computer.

Limitations

- Some part-processes may not lend themselves easily to automation.

Capital costs

- About US $10-20,000 for a batch-wise dyeing machine;
- About US $2-300,000 for a complex continuous machine, and US $10,000 to 50,000 for central computer.

Diffusion

Microprocessor-based process controllers have been available since the mid-1970s for batch-wise (discontinuous) dyeing machines. They have been widely used in the past five years in dye-houses all over the world, including the more modern factories in developing countries. Fully-automated dye-houses with central computers and process controllers for printing have only recently been introduced on an industrial scale.

Quality Control (QC) -

6. On-line data input for QC statistics

Inspection tables can be equipped with keypads (simplified keyboards) connected to a computer, so that quality controllers can mark each fault in the grey or finished fabric without stopping the running of the fabric.

Preconditions

- Full system analysis of QC process, and eventually modification of fault-coding system is necessary before automation;
- Installation of inspection tables where previously not available.

Advantages

- Increased productivity;
- Improved management information system.

Limitations

- Only a limited number of fault codes may be used (up to 10-14 vs. the often 50-60 different codes in conventional QC);
- Faults are marked with paper labels (not thread), which may be unacceptable for some markets.

Capital cost

- About US $20,000 for one inspection table; and additional US $30,000 - 50,000 for central computer.

Diffusion

Some early attempts at the diffusion of this technique were made in the late 1970s. In the past few years it has been rapidly gaining ground in the developed countries.

7. Production planning/control, management information system

This covers everything from simple inventory/stock control, on-line acquisition of production data, mill balance calculations to management decision support systems.

Preconditions

- Full knowledge of every aspect of the activities to be computerised is vital; implementation must always be preceded by in-depth survey/analysis.

Advantages

- Improved performance of areas covered.

Limitations

- Deep involvement of the management both at the top and at the medium level is essential;
- Preparations may take fairly long time before results can be realised.

Capital cost

- From US $2-3,000 for some simple data processing on a PC up to even US $1 million and over for full computerisation of all major activities of a factory or company.

Diffusion

Beginnings in the diffusion of this technique go back to the 1960s, but its widespread use began only in the 1980s with the advent of high-power professional personal computers. Now the use of computers in production/ management in one form or another is taken for granted even in most developing countries. Fully computerised operations can be found only in some of the most advanced factories/companies in developed countries.

CHAPTER III

SOCIOECONOMIC EFFECTS OF APPLYING CAD/CAM TECHNIQUES IN THE CHINESE SILK INDUSTRY

Silk industry is one of the oldest traditional industries of China. Today China is the largest producer and exporter of silk and silk products in the world. During 1980-87 silk cocoon production increased by 34 per cent, production of raw silk by 41 per cent, and of silk fabrics by 50 per cent.

RECENT TRENDS IN THE SILK INDUSTRY

The physical production of Chinese silk has grown from 1,800 tons in 1949 to nearly 45,000 tons in 1986. In terms of gross output the value of silk textiles has increased from 54,300 million yuan in 1980 to 111,500 million yuan in 1985, that is, output more than doubled. The net output of silk (at current prices) incre[illegible] from 1,442 million yuan in 1980 to 2,657 million yuan in 1985 (See Annex III).

There are 820 silk factories engaged in such production processes as reeling, weaving, dyeing, printing and finishing. In terms of ownership, both village/township collective enterprises and state-owned enterprises are found in the industry. There are no private enterprises because of the high capital costs involved. However, some limited amount of silk reeling is done at the cottage industry level, mainly by women within rural households.

The industry provides livelihood to about 650,000 people. It is a labour-intesnsive industry with low productivity and traditional technology. Besides employment in the silk industry several million rural households are engaged in silk cocoon production.

At present China exports about equal proportions of a) raw silk, b) silk fabrics, and c) silk garments. In future, it intends to raise the proportions of (b) and (c), by processing raw silk before exporting it. In the recent years exports of processed silk have started rising: the share of silk fabrics in total exports went up from 34 per cent to 38 per cent whereas the raw silk exports declined from 49 per cent to about 42 per cent between 1981 and 1985. Further expansion of exports of silk products would depend on the extent to which China can successfully compete in the foreign markets by lowering costs, raising quality of products and responding quickly to changes in fashion and consumer taste.

In the past, all silk exports were handled by the China National Silk Import and Export Corporation (CNSIEC). Under the new policy of decentralisation and deregulation, individual export-oriented factories are now authorised to export silk directly without going through CNSIEC.

The trends in growth of output, per capita consumption and exports of different types of textiles including raw silk and satins are given in Table 1 which shows that the rate of growth of output of silk during 1975-80 was much lower than the growth of per capita consumption of silk and satins. In other words, the present demand for silk exceeds its supply. There is a growing foreign market for silk fabrics and garments for both high fashion products and mass-produced silk products.[1] There may also be

1. See A. Hyvarinen, Export Development Support to Selected Enterprises in Asia and the Pacific Producing/Exporting Silk and Products - A Demand Study, UNCTAD/GATT International (Project No. RAS/47/22), Geneva, 2 June 1987.

scope for future export of home furnishings - silk curtains and upholstery - from countries like China. The rising domestic demand for silk need not adversely affect exports of Chinese silk provided two major problems, viz. supply of raw materials (cocoons) and low levels of technology,are solved. These issues are discussed below.

Supply of silk cocoons

Although the output of silk cocoons has grown in the past few years especially since the introduction of rural economic reforms, it is far below the demand from the silk factories and rural households.

One of the reasons for the failure of output to catch up with demand is the lack of incentives for peasants to do silk farming. The price of silk cocoons is lower than for many other cash crops. While the price of cotton (a basic necessity) is fixed and controlled by the State, that of silk cocoons is not - it is fixed by the local governments in different provinces. The State felt that the deregulation of price control would enable cocoon-producing provinces and local governments to earn revenue and foreign exchange through exports in conditions of booming demand for silk cocoons. But in the absence of any mechanism for macro management the policy of price deregulation seems to have backfired.

There is a big difference between State and non-State price of silk cocoons which is being exploited by speculators in search of quick profits. The result is serious shortage of raw material and resulting high prices. Thus shortage is not necessarily due to low production but also due to hoarding, speculation and distribution bottlenecks.

TABLE 1

Growth Rates for the Chinese Silk Industry

(Annual compound rates of growth)

ITEM	PERIOD				
	1952-57	1957-65	1965-75	1975-80	1980-85
Growth of physical output of silk	12.1	-1.0	9.8	8.9	-
Growth of output of silk cocoons	-1.9	-0.8	6.3	10.9	-
Growth of output of:					
a) cloth					1.72
b) chemical fabrics					16.0
c) woollen fabrics					16.7
Growth of per capita consumption of:					
a) cloth	3.6	-1.2	2.1	5.6	3.1
b) woollen fabrics	0.0	14.7	7.2	18.5	15.7
c) silk and satins	14.9	3.3	6.8	12.5	13.8
Growth of Exports of:					
a) raw silk	9.8	-1.7	5.5	9.8	-
b) silk and satins	25.7	7.2	2.0	2.7	-
c) silk fabrics					

Sources: For output of silk cocoons, Dwight Perkins and Shahid Yusuf: Rural Development in China, Johns Hopkins, University Press 1984. For other data, Statistical Yearbook of China, 1986.

Another reason for the shortage of cocoons is competition between village/township silk enterprises and the larger state-owned silk factories. The uncontrolled growth of the former (including silk reeling by rural households) has encouraged farmers to withhold certain proportion of production of cocoons for rural use. The Institute of Rural Development of the Chinese Academy of Social Sciences recently did an investigation of the silk cocoon production in Suzhou in Zhejiang province. It noted a severe competition between rural producers and urban silk industry. The local government had stipulated that farmers must sell their cocoon output for use by state-owned factories but the latter continued private sale of cocoons to rural households and village enterprises.

Technology and investment

The technological levels of the Chinese silk industry are generally rather low. The Chinese government has relied on indigenous technology for silk reeling whereas for silk weaving, imported technology is also used. The dyeing technology is of a slightly higher level than the printing technology which lags behind but in which advanced countries have made rapid strides. All three levels of flat-screen printing (hand, semi-automatic with carriages and automatic tables) are currently used in the Chinese silk industry, the conventional hand-printing technology being the most predominant. Recently microprocessor-controlled carriages have also appeared in at least one factory.

At present, the Chinese silk factories have very long cycles of production which prevents them from responding easily and quickly to fluctuations in demand abroad resulting from change in fashion and consumer tastes. The use of CAD/CAM techniques should offer the needed flexibility to enable enterprises to respond quickly to changing demand by producing wider varieties.

The Chinese investment policy pays greater attention to the renovation and improvements of existing silk factories than to new investments. In 1985 the total investment in new construction of silk factories amounted to only 58 million yuan compared to 91 million yuan for the expansion of existing capacity. Reconstruction and technological improvements accounted for additional 24 million yuan (see Annex III). In Shanghai silk factory No. 7 (visited by the Mission team) at the end of 1987, total investment was as follows: 11.9 million yuan for reconstruction, 4.8 million for expansion, 4.87 million yuan for machinery and 7.0 million for new construction.

The policy of decentralisation has reduced government control of investments. Eighty per cent of the total investments in China is currently controlled by the local governments and the enterprises. Therefore, in the absence of appropriate mechanisms for macro management of the economy it may not be easy to implement fully government's policy of giving priority to technological improvement over capacity expansion. And capacity expansion may in fact be desirable in the long run for the silk industry to meet growing domestic and foreign demand.

RURAL-URBAN LINKAGES

Linkages between different economic activities in urban and rural areas can occur when expansion in the output of one sector leads to an increase in the final and intermediate demand for outputs and inputs of other sectors. Backward linkages are those which lead to new investments in input-supplying industries (silk cocoons in the case of silk industry) and forward linkages are those which induce investments in output-using industries (like fashion and garments industry). As menand for the output of the silk industry expands, in principle additional demand for the raw material inputs (e.g. silk cocoons) should increase investment and output of the material supplying industry. However, as discussed earlier due to distorted prices and shift of investment away from agriculture, new investments in silk farming do not seem to have occurred. A broad-based rural development strategy with an egalitarian income distribution should lead to demand or consumption linkages for both rural and urban non-agricultural commodities. In China, it seems that intra-rural linkages have so far been far more important than urban to rural linkages. As a result of the rural economic reforms, growth in farm incomes has induced the development of rural industry and sideline activities within the rural sector. A policy of priority to consumption over investment should in principle raise the scope for consumption linkages between rural and urban areas, but this seems to have occurred mainly for urban consumer durables rather than for silk and silk garments.

The effect on the rural and urban consumption of silk fabrics and garments would depend on the rate of growth of incomes of different income groups and the income and price elasticities of demand for silk and silk goods compared to those for cotton and wollen substitutes. In future, with a continuous rise in rural incomes the rural demand for silk and silk products is also expected to grow. A sample survey of urban households undertaken in 1985 divided them into several income classes and estimated per capita physical consumption of different types of cloth and garments. The sample data are presented in Table 2. As is to be expected, cotton cloth registers highest consumption for all income classes, followed by synthetic cloth. The per capita urban consumption of silk and satins at present is rather low, ranking third before woollen fabrics. However, as one moves along the income classes from the lowest to the highest class, the demand for cottom cloth nearly doubles whereas that for silk and satins triples. This suggests that at higher income levels the richer people in urban areas tend to substitute silk for cotton since the former carries greater prestige and social status. Among the lower-income groups the demand for synthetic fibres and garments is much higher than for silk presumably because the former are cheaper and more durable.

No separate information is available on per capita rural consumption of silk by income categories. It is therefore not possible to compare rural and urban per capita consumption. However, one would expect that at higher levels of incomes rural people would tend to rely more on cotton and synthetic textiles. This seems to be suggested by the low rates of annual growth in consumption of silk and satins in rural areas during 1980-85 compared to much higher growth rates for woollen and chemical fabrics (see Table 3).

Apart from output and consumption linkages noted above, employment linkages between urban and rural areas need to be considered separately since maximisation of production linkages need not necessarily maximise additional employment.

In China, the planners and policy makers need to consider employment generation as an integral part of their development strategy. As absorption of surplus labour is a key issue, it would be appropriate for Chinese economic and social institutions like the Institute of Economics and Industrial Economics of the Chinese Academy of Social Sciences (CASS) to undertake studies of direct and indirect employment effects of different economic activities.

Using the Chinese input-output table for 1981, the economist member of the Mission team made preliminary estimates of output and employment linkages of the textile industry (separate data for the silk industry are not available) with other sectors. The results show that the textile industry performs better in respect of output linkages than in respect of employment linkages. The ranking of textile industry among the industrial sectors, in terms of output and employment linkages is given below:

Textile Industry	Rank
Backward Linkages	
Direct and indirect output linkage	2
Direct and indirect employment linkage	5
Forward Linkages	
Direct and indirect output linkage	1
Direct and indirect employment linkage	11

TABLE 2

Per Capita Urban Consumption of Textiles and Garments by Income Classes (1985)

Item	Unit	Total Average	Income classes (by per capita monthly income)					
			Low	Medium low	Medium	Medium high	High	Highest
COTTON TEXTILES								
Cloth	metres	2.71	2.34	2.41	2.75	3.08	3.27	4.08
Clothes	pieces	0.51	0.45	0.47	0.53	0.56	0.58	0.62
WOOLLEN TEXTILES								
Fabric	metres	0.44	0.32	0.32	0.43	0.51	0.67	0.84
Clothes	pieces	0.23	0.14	0.18	0.23	0.28	0.35	0.43
SYNTHETIC FIBRE								
Cloth	metres	2.10	1.75	1.88	2.22	2.32	2.54	2.90
Clothes	pieces	1.34	1.10	1.26	1.38	1.48	1.66	1.80
SILK TEXTILES								
Silk & satins	metres	0.65	0.42	0.50	0.64	0.76	0.97	1.20
Clothes	pieces	0.11	0.07	0.09	0.10	0.12	0.14	0.16

Source: Statistical Yearbook of China, 1986, p.581.

TABLE 3

Growth of Annual per Capita Consumption of Different Types of Textiles and Clothes in Chinese Urban and Rural Areas

(Percentages)

Item	Annual Growth Rate		
	Rural (1980-85)	Urban (1981-85)	Total (1980-85)
COTTON TEXTILES			
Cotton	2.5	-	3.1
Cloth	-10.0	15.0	-
Clothes	-	2.1	-
WOOLLEN TEXTILES			
Fabrics	18.5	19.0	15.7
Fabric clothes	-	20.2	-
Knitting wool & knitwear	-4.36	-	-
SYNTHETIC FIBRE			
Cloth	21.6	-	-
Clothes	-	16.4	-
SILK TEXTILES			
Silk & satins	3.13	10.9	13.8
Silk & satin clothes	-	53.1	-

Source: Statistical Yearbook of China, 1986, pp.578 and 585 and 596.

- = not available.

Employment linkages of the silk industry with rural areas can in principle be promoted through sub-contracting of such processes as reeling and weaving by urban factories to rural township enterprises which have rapidly developed in China and continue to thrive. At present in the case of the Chinese silk industry there seems to be little sub-contracting to rural areas. The Mission team was told that large silk factories were afraid of getting poor quality work. In the past sub-contracting seemed to be more prevalent but since the rural economic reforms and growth of village and township enterprises, a growing competition is noticeable between large factories and rural industry. There seems to be reluctance on the part of rural enterprises to work for large factories on a contract basis.

Yet the experience of Japan and the Republic of Korea indicates that sub-contracting can promote important technological marketing and employment linkages between rural and urban areas. The collaboration among small silk enterprises in Korea for technology diffusion is relevant here. The example of Shibori (silk material for kimonos) processing in the rural areas of Korea was started in 1920s by a number of Koreans returning from Japan. Many of these experienced craftsmen demonstrated silk processing techniques to their neighbours in their living rooms and/or at short training courses held in village halls and school buildings. This example of the willingness of craftsmen to share acquired knowledge and skills may be peculiar to the cultural and social homogeneity of Japan and Korea.[1] But it would seem that a similar motivation towards technology diffusion could occur through collective

1. Susumu Watanabe (Ed.), Technology, Marketing and Industrialisation - Linkages between Large and Small Enterprises, Macmillan Press, New Delhi, 1983, pp.231-32

organisation of production in China. However, the rural economic reform has led to decollectivisation which seems to have reduced the importance of the above types of technology diffusion and linkages in the rural areas.

It may be desirable to study, under the SPARKS programme, the ways and means of promoting technological linkages of the Chinese silk industry with production in the rural sector.

SOCIOECONOMIC EFFECTS

Three main types of socioeconomic effects of CAD/CAM and related computer applications may be considered. These are:

1. Employment effects,
2. Skill requirements and implications for training, and
3. International competitiveness and foreign exchange earnings.

Before analysing these effects, it is useful to examine the main motivation of enterprises to use computer-based technologies. In the silk industry, computer applications including CAD/CAM are illustrated in Table 4 which shows that the impact of technology is felt in various ways, viz. savings in labour, energy and raw materials; increase in productivity resulting from reduction in time required in drawing, redrawing and designing; improvement in product quality through shortening of lead and deliverty times, etc. (For details see Chapter II). This last advantage is particularly important in silk industry which is vulnerable to frequent changes in fashions. The above characteristics of CAD/CAM and computer applications offer silk enterprises considerable marketing advantages since they can give detailed quotations of price, design patterns and product quality more quickly.

However, the above benefits would need to be weighed against the high capital costs involved in acquiring the computer technology and training costs incurred in effectively utilising and mastering it. Some idea of the very high capital costs for computer and CAD/CAM applications can be given by the following illustrative figures:

Technology	Capital Costs (US $)
1. Computer-aided Design	200,000 to 2 million
2. Computer-controlled colour kitchen	200,000 to 300,000
3. Automatic manufacturing of printing screens	700,000 to 1 million.

One of the important reasons for using CAD/CAM techniques is the need to improve product quality. But quality requirements vary between domestic and foreign markets. This is particularly true in the case of the silk textiles which are subject to differences in tastes, fashions and motifs in China and the advanced countries. The product quality characteristics demanded by the Chinese consumers are likely to be less demanding than those needed for the export markets. Indeed, it may be easier to satisfy the domestic market with the use of conventional technology producing to less sophisticated standards of quality especially if they are accompanied by relatively lower product prices. However, in the case of export markets international competition and increasing number

TABLE 4

Application of New Technologies in the Silk Industry

Technology/ Process	Description	Impact	Limitations
Design/Pattern making	- Computer-aided design (CAD): use of computer graphics for generation of patterns, "reading in" motifs with a camera or scanner, making of hard copy of design on colour printer.	- Shortens response and delivery times (from 1-2 months to a few hours) for customer's design approval and 1-2 weeks for delivery. - Saves labour of technicians and designers; - directly applicable independent of subsequent processes.	- Some designs cannot be processed by CAD.
Dyeing	- Computerised colour measurement and colour matching; - automated colour kitchen.	- Increases repeatability of dyeing/printing process; improved dyestuff stock control and pricing; saving in labour.	- Need for consistent dyestuff quality. - Large space requirement.
Printing	- Automatic computer-controlled printing "tables;" - automatic manufacturing of printing screens (computer-aided flat or rotary printing screens).	- Reduces delivery time; quality improvement; saving in labour, energy and materials; reduces the need for screen corrections.	- Same as for CAD (No. 1 above)
Finishing	- Computer process control; - computer use in the control of inventory/stocks and data collection.	- Increases productivity; - saves labour, energy and materials; - raises quality through higher reproducibility.	- Need for involvement of top and middle level management. - Need for detailed and advance planning of production, work organisation, etc.

of computer applications in the silk industries of the advanced countries makes it imperative for China to narrow the technological gap and produce very high-quality products for the export markets.

The silk industry is known to be much less dependent on price competition than on quality competition. This factor partly affects the nature of technological innovations required. Apart from computer control in processes like dyeing and printing, efficient product marketing and co-ordination of different processes in the production cycle may also be very important.

The use of CAD/CAM techniques is not the only path towards technological modernisation of the Chinese silk industry. Upgrading of technological levels, productivity and product quality improvements can be achieved in several alternative ways. In many cases organisational innovations can considerably raise productivity even with the existing conventional technology. Installed capacity can be fully utilised through multiple shifts (it is reported that in the Chinese silk factories excess capacity is growing as a result of raw material and power shortages); managerial efficiency can be improved through better work organisation and skill upgrading. Indeed the silk factory which the Mission team visited in Shanghai seems to be producing high-quality silk for exports, thanks to its skilled labour force and efficient managerial staff. At the factory level, there seem to be wide variations in labour productivity, machine productivity, energy consumption, rate of machine utilisation and profitability of capital investment. (See Table 5). These variations seem to be due to differences in managerial and worker efficiency, and equipment vintage.

TABLE 5

Basic Economic Data on Key Silk Factories in China

Item	Unit	Shanghai			Hangzhou	Others	
		Dyeing and Printing Factories			Dyei and printing factory (1983)	Dan Dong factory (1983)	Shuzhow Sen Ya factory (1983)
		No.1 (1983)	No.2 (1983)	No.7 (1987)			
Output of silk products	(000 metres)	19,690	14,770	2,203	41,160	6,060	11,840
Total staff		3,450	3,746	607	5,715	3,158	3,675
of which workers	(No.)	2,661	3,021	399	4,661	2,463	2,727
Physical output per worker	(000 metres)	7.4	4.8	5.6	8.8	2.5	4.4
Annual value output per worker	(10,00 Yuan)	1.37	1.37	3.71	1.90	2.07	2.05
Output per silk weaving machinery	(metres)	3.1	2.3	-	-	-	2.6
Energy Consumption per unit of output	(tons per 10,000 Yuan output)	1.08	1.21	-	1.85	2.41	1.47
Machine utilisation rate	(%)	96.0	96.2	73.7	-	-	90.0
Profitability on capital	(%)	66.5	37.8	26.2	32.3	13.9	34.1

Sources: (1) Industrial Development of China, 1949-1984 (In Chinese), Beijing, p.171; (2) Data for Shanghai factory No.7 were collected through factory visits.

Thus an appropriate technology policy for the Chinese silk industry would be a combination of high technology and conventional production methods (what is known as technology blending). It was noted in Chapter II that CAD applications can be made independently of the technical levels of the subsequent processes. This implies that its applications do not call for the technological upgrading of other processes. However, this is not the case in the application of other computer technologies like the computer colour matching or computerised process control. The preconditions for using these latter technologies are outlined in detail in Chapter II. The policy of technology blending will mitigate the social costs of labour displacement and skill requirements that may be involved in the widespread switch to high technology. It also requires smaller investment outlay and draws upon existing skills besides being more suited to local conditions.

In the light of the above general considerations, the employment, training and trade effects of CAD/CAM techniques are examined below.

Employment Effects

The computer applications to silk industry, noted in Table 4 and described in detail in Chapter II, are known to be labour saving. As the Chinese silk industry employs a large number of people it is important to assess possible negative employment implications of the use of CAD/CAM techniques throughout the Chinese silk industry. It is, however, too early to quantify such effects since (as noted in Chapter II) these applications are very recent even in the advanced countries, not to speak of China where only a small number of factories at the top end of the technological spectrum have just begun introducing computer-based technology on an experimental basis. Furthermore, at present computer applications are being made more in management and cost accounting than in actual production processes. Another complicating factor is the long-established Chinese labour policy under which factories could not lay off any labour. Under the new urban reforms, the factories are in theory allowed to hire and fire workers but in practice the new policy has not yet been implemented partly because the displaced labour is unlikely to find any alternative employment under conditions of growing surplus labour. This means overstaffing and low labour productivity even in those factories which have undergone technological modernisation.

However, labour redundancy at the factory level does not occur due to the use of computer-based technology alone. It may also occur due to several other factors: reorganisation of work and production, better plant layout, stagnant market demand and economic recession, etc. At a broader macroeconomic or industrial level the total employment effect of computer applications may in fact be positive in conditions of rapidly growing demand and output. In the case of the Chinese silk industry, there is potential for expanding output to meet domestic and foreign demand for silk. If this potential can be exploited, rapid output and productivity growth could generate indirect employment to compensate for any loss of jobs attributable to CAD/CAM and other computer applications. The bottleneck in the expansion of output is not the demand but the supply factors like shortage of raw materials and energy.

Finally there is another issue which the Chinese planners and policy makers, particularly in the State Science and Technology Commission, need to bear in mind. In the foreseeable future, the computer-based technologies including CAD/CAM will have to be imported from abroad. This means that the potential positive employment and learning effects of the manufacture of these technologies will not occur in China.

Skill Requirements and Implications for Training

The main influence of the use of CAD/CAM techniques occurs at the lower end of the skill ladder. The effect is mainly in the form of de-skilling of jobs of technical designers in the studio or technicians on the shop floor, since CAD/CAM considerably reduces the need for routine work. At higher level of skills such as designers (artists) or colourists the use of CAD/CAM tends to upgrade skills and enhance creativity by giving the artist and the technical professional new powerfull tools. New skill requirements relate to three types of operations, viz. (i) system handling, (ii) design effective operations, and (iii) checking operations.

In the Chinese silk industry a number of universities and colleges relating to textiles give training courses in silk design and manufacture. Currently, for silk production two types of training are being given: a) young graduates who are familiar with the use of computer are being trained in silk technology, and b) technicians in silk factories who are familiar with silk technology are being trained in the use of computers.

The Shanghai Silk Factory No.7 visited by the Mission team has a plan to establish in 1989, a training centre to train its technicians in computer technology. It would be desirable to open up these training facilities to technicians from other factories in Shanghai and elsewhere in order to i) ensure maximum utilisation of training capacity and ii) diffuse computer technology more widely within the silk industry. This sharing of training and exchange of technology could be promoted in two ways. First, the silk corporations may organise collective training courses for a number of state-owned factories. Secondly, the factory with training facilities could offer these facilities to other factories for payment of a service charge.

In the long run, some thought will need to be given to the retraining and redeployment of skilled manpower which might become redundant as a result of more widespread use of computer-based technology in the Chinese silk industry. In the case of the Shanghai Silk Factory No.7 visited by the Mission team, the factory director was confident that the designers and other staff who might become redundant could be trained to man the new export department which needs to be set up by the factory to export directly to foreign countries which is made possible under the urban economic reforms. However, it is doubtful whether the specialised designers could be easily trained as salesmen and marketing personnel. In the interest of promoting occupational specialisation, it would be more appropriate for the labour bureaus to retrain and redeploy any redundant labour in other silk factories or in related technical occupations.

International Competitiveness

By enabling better quality control, repeatability, consistency and flexibility, computer-based technologies provide an opportunity to developing countries to effectively compete in the foreign markets. At present China suffers from severe competition in these markets because of poorer quality of products and higher costs of production. Costs of production for export markets may include material cost, labour cost, overheads, cost of transport and costs associated with tariffs imposed by some advanced countries on the imports from developing countries. In the Chinese silk industry CAD/CAM techniques are likely to save material and labour costs but in China the latter are much lower than in European countries. China therefore needs to introduce these techniques more for reasons of speed, quality and flexibility than for cost reduction.

Another compelling reason for China to introduce high technology in the silk industry is the fact that many advanced countries producing silk (Italy, the Federal Republic of Germany and Switzerland) are rapidly introducing these techniques in their silk industries. In order to narrow the technological gap China has no choice but to make computer applications to maintain foreign markets and expand its share of the markets for processed silk fabrics and garments in keeping with its policy of substituting exports of dyed and printed silk for the exports of raw and grey silk.

Increase in China's exports of silk can raise foreign exchange earnings which in turn can facilitate the process of technological modernisation now underway in the silk industry as well as in other industries. However, this issue is not as simple as it appears at first sight. The new techniques like CAD/CAM and computerisation of management and production planning are labour saving and involve higher capital costs than conventional techniques. The Chinese silk industry currently offers employment to a large number of people and the government is quite concerned about growing labour surplus in the economy. Therefore, social cost of possible labour displacement due to a widespread introduction of CAD/CAM and related computer applications in silk industry will need to be balanced against the expected benefits in terms of foreign exchange earnings through improved export competitiveness.

CONCLUSIONS

It is clear from the foregoing analysis that the Chinese silk industry needs to adopt a two-pronged approach to technological modernisation. Efforst need to be made to improve existing conventional technology (labour intensive or automated) through adaptation and improvements in equipment and organisation as well as upgrading of managerial and worker efficiency. Both hardware and software are important for effective utilisation of modern technology. At the same time a selective use of computer-based technologies including CAD/CAM, particularly in production for the export market should also be made in a) design and printing, b) production planning and management, and c) information exchange. In the planned economy of China, this technology blending strategy should not be difficult to implement considering that the silk industry is divided along domestic and export segments of the market. For example, a number of factories have been designated by the State for production almost exclusively for the export markets. In the initial stages of CAD/CAM applications priority should be given to these export-oriented factories.

A selective use of CAD/CAM and related computer applications will require formulation of appropriate measures for the planning and management of i) price of raw materials like silk cocoons, and ii) allocation of raw material supplies between village/township enterprises (which the State promotes) and the state-owned factories producing mainly for exports. In the absence of adequate and regular supplies of raw material to silk factories it would not be possible to utilise fully the installed silk-producing capacity to satisfy growing demand. Neither will it enable the maximum utilisation of costly computer-based technology.

The government needs to introduce economic incentives for farmers to grow more silk cocoons to meet rapidly expanding demand. To provide these incentives and to check inter-provincial competition in the procurement of silk cocoons, the following measures may be considered:

a) raising the purchase price of silk cocoons to make their production more attractive, and

b) transferring a certain proportion of the growing profits of rural industry for investment in sericulture and cocoon production.

Within the framework of the SPARKS programme, studies should be undertaken of the ways and means (e.g. through sub-contracting) of promoting technological and other linkages of silk industry with the rural sector, particularly with the village and township enterprises.

Socioeconomic cost-benefit studies on the application of computer-based technologies including CAD/CAM in the Chinese silk industry should be undertaken with the assistance of institutions concerned with the broader macroeconomic analysis (e.g. the Institute of Industrial Economics of the Chinese Academy of Social Sciences which is well staffed). Such institutions can offer useful consultancy services to the National Silk Corporation and the State Science and Technology Commission. The studies would go a long way in discouraging the hasty and sometimes wrong type of expensive technology imports and thereby avoid waste of scarce capital and foreign exchange resources. In doing these studies and appraisals, the following checklist of benefits and costs of using CAD/CAM techniques may by considered:

* motivation for the use of CAD/CAM,
* savings in labour in drawing and design,
* savings in working and fixed capital,
* savings in materials and energy,
* reduction in delivery time and its implications,
* increase in quality, consistency and repeatability,
* requirements of management and operator skills,
* diffusion of technology within the silk industry and problems encountered,
* effect on export market share and foreign exchange earnings,
* cost of acquiring technology from abroad,
* facilities for the repair and maintenance of imported technology and the cost involved.

CHAPTER IV

MODE AND ROUTE FOR INTRODUCING CAD/CAM TECHNIQUES IN SILK DYEING, PRINTING AND FINISHING IN CHINA

Due to the limited time available for the Mission only three factories (selected by the Chinese authorities as the most appropriate counterpart production units) were visited. The picture that emerged from these visits to the silk dyeing and printing factories is not unlike that of other sectors of the textile industry in China. Even the most advanced factories (and the ones visited by the Mission team were said to belong to this category) have production machinery ranging from the very basic (sometimes just simple, sometimes fairly old as well) to the latest, most sophisticated.

The quality of the products is generally high. In export-oriented factories, the quality reaches the upper medium level of that prevailing in the developed countries. In the case of printed silk fabrics the difference between the top quality produced in the developed countries (e.g. in Italy) and that in China lies in:

a) the design (how fashionable and demanding it is);

b) the execution of that design on fabric (i.e. print quality);

c) the fabric (particularly handle and drape);

d) response time (i.e. confirmation of the customer's order, and then delivery).

The following pages describe how the introduction of CAD/CAM techniques may help the Chinese silk industry in narrowing the gap between the demands of the top end of the market and the present possibilities of the Chinese silk dyeing and printing factories.

1. Computer-aided design (CAD)

CAD facilitates fast adaptation of the latest design elements of current fashion; also it significantly reduces the response time. The precondition for familiarising the eventual users of the CAD system with it can be fulfilled in three stages: (i) full involvement in the selection of the system by making a study tour to a number of potential suppliers; (ii) training by the supplier at installation and start-up; (iii) subsequent training by international experts through seminars, courses and eventual fellowships.

One of the main reasons why CAD should be selected as the first field of possible computer applications is that a "model" or demonstration unit operating on a commercial scale can supply a number of factories not only with information and training, but also with designs or even colour-separated transparencies. Since the application of CAD is possible,even in factories using hand-printing, the advantages of this technique can be brought to factories where other computer applications cannot as yet even be considered.

In this context, however, it is unlikely that a factory importing the new technology will have any incentive to share it, especially in conditions of growing competition among factories for capturing export markets. The role of local government institutions like the provincial and district branches of the science and technology commissions and the silk corporations in promoting technology diffusion, may therefore be important.

One precondition of an eventual CAD/CAM project should thus be a commitment (in some form of a binding contract) from the counterpart factory to promote such wider utilisation of the system in the form of seminars and training courses to illustrate the application possibilities for others, and also by serving as a CAD-centre, selling (in an appropriate manner) designs, or allowing other factories to use the system for their own designs. It must be emphasised, that there are technical possibilities to prevent unauthorised access to any of the designs processed on the system.

2. Automatic manufacturing of printing screens

The automation of screen making with conventional and - as compared to the computerised version - significantly less expensive machinery is already available or has been decided upon in some factories. This is a good alternative to computer-aided screen manufacturing which, due to relatively high capital costs and low return on investment, may not be feasible at this point in time.

3. Colour matching: colour measurement and recipe prediction (CCM)

CCM contributes to cost effectiveness and also to the reduction of response time. The equipment is available in a number of factories, but it is not yet fully utilized in most cases.

External help is needed in the form of seminars and training courses on the use of colour measurement and colour matching techniques, and it is proposed, that such help be considered as part of an eventual technical assistance project.

4. Automated colour kitchen - controlled weighing

Computer-controlled weighing of dyestuffs improves the repeatability of the dyeing/printing process, and thus reduces costs and improves quality of the final products. This can be introduced without investing in a fully-automated colour kitchen for which the preconditions are not yet met in the Chinese silk industry. The relatively small capital investment compared to the significant results to be expected justify further consideration of this technique.

CCM systems can handle the computing tasks involved in controlled weighing; therefore an attempt should be made to incorporate this part into the better utilization of CCM equipment (see under 3. above).

Automated colour kitchens are not as yet feasible in either dyeing or printing silk processes in the Chinese silk industry because the capital costs are disproportionately high comapred to the benefits to be expected under the present circumstances.

5. Process control

Although some dyeing and printing machines equipped with sophisticated process controllers do operate in the silk industry, it is neither expected nor feasible to use microprocessor-based process controllers in the near future.

In some cases however, where preconditions can be fulfilled and quality requirements cannot otherwise be met it may be desirable to purchase some machines (in the first place printing carriages) with process controllers. In the area of dyeing, other sectors (e.g. cotton) may introduce dyehouse automation at an earlier time, and it would be advisable to study the results achieved in those factories.

6. Quality Control (QC) - On-line data input for QC statistics

The primary advantage of this technique, increased productivity in terms of labour rather than equipment, is obviously far less important in China than in Europe or the United States. Investing in the automation of fabric inspection may thus not be justified.

Improving the management information system on the other hand, would help companies in improving quality of their products, since causes of faults an be traced back and analysed much faster than by conventional methods. On the hardware side this would only need a PPC (professional personal computer) readily available in factories.

External help may be needed in making the system analysis, and some guidance would be required in writing the software. This help should take the form of study tours to see such systems in operation, and lectures on the concept of quality control statistics and their use.

7. Production planning/control, management information system

In certain areas PPC's (mainly IBM XT-s, AT-s or compatibles) are already used in the Chinese silk industry. To widen the range of applications more information is needed on the possibilities, and this can be acquired during study tours abroad, from the literature and from talks, lectures, seminars on the topic. External assistance in this respect should be provide through the usual channels of information transfer.

For more ambitious applications, such as complex management information systems the Chinese silk printing and dyeing industry does not appear to be ready yet. However, since the preparations for the introduction of such a system take very long (several years), preliminary studies may be conducted on the viability of such projects.

CHAPTER V

NEED FOR EXTERNAL ASSISTANCE

The silk dyeing and printing industry in China has already started to introduce CAD/CAM techniques; in some cases on a commercial scale, in many cases only as exercises with no direct application possibilities. The technical level of the industry permits, and the quality (particularly export) requirements necessitate faster progress in this field.

Due to financial constraints on the one hand, and lack of adequate information on the other, this faster progress can only be achieved if external technical assistance is also provided. For the assistance to be effective it must contain two main elements: equipment and expertise.

The best overall benefit-cost ratio is to be expected from computer-aided design (CAD), primarily because the efficiency of this technique is practically independent of the technical level of the subsequent processes. It is also this field of application where results can be achieved in a relatively short time. As a first stage a CAD system with design, editing and colour separation capabilities, and a full colour printer to provide fast response to customers' demands may be aimed at, at a current price-level of around US $3-400,000. External assistance may be needed in system selection, start-up and subsequent training.

In addition to CAD expertise and training, the following areas should also be considered:

* colour measurement and colour matching;

* dye-house automation (computer-controlled weighing and application of process controllers);

* computer applications in quality control.

Computer-controlled weighing of dyestuffs improves the repeatability of the dyeing/printing process, and thus reduces costs and improves quality of the final products. This can be introduced without investing in a fully-automated colour kitchen for which the preconditions are not yet met in the Chinese silk industry. The relatively small capital investment required and the significant results that can be expected justify further consideration of this technique.

ANNEX I

PRINCIPAL CONTACTS IN CHINA

I. BEIJING

1. **State Science and Technology Commission**

- Yaó Erxin, Assistant Director, Department of International Cooperation.
- Qian Jingjing (Ms.), Deputy Division Chief, Department of International Cooperation.

2. **Ministry of Textile Industry**

- Zhu Xing, Senior Engineer, Department of Foreign Affairs, Ministry of Textile Industry.
- Zhang Linquan, Deputy Chief Engineer, Silk Administration Bureau.
- Xu Xingong (Ms.), National Silk Administration.

3. **Institute of Industrial Economics, Chinese Academy of Social Sciences**

- Zhou Shulian, Director.
- Yang Mu, Deputy Director.

4. **Institute of Rural Development**

- Chen Jiyuan, Director.
- Du Xiaoshan, Chief of Research Coordination Division.

5. Institute of Economics, Chinese Academy of Social Sciences

- Yu Da zhang, Chief, Section of Comparative Economics.

- Xiang Qiyuan, Research Fellow, Economics Institute and Secretary General, Council of the Almanac of China's Urban Economy and Society.

6. People's University of China

- Prof. Yu Xueben, Chairman, Economics Department.

7. University of International Business and Economics

- Prof. Sun Yonghong, Department of Economics.

8. United Nations Development Programme (UNDP)

- Caterina Benerdelli (Ms.), Programme Officer, UNIDO Associate Expert.

II. SHANGHAI

- Gu Chuan-xun, Vice-Mayor, Shanghai.
- Ding Li, Deputy Director, Shanghai Textile Industry Bureau.

- Zhou Yongping, Deputy General Manager, China Textile Machinery Technology Import and Export Corporation.

- Huang Yi Zing, Director of Shanghai Textile Science and Technology Development Centre.

- Hu Jia Lun, Engineer, Science and Technology Commission of Shanghai Municipality.
- Lu Jingchang, Vice Manager' Shanghai Silk Corporation.

- Lin Vin Zhong (Ms.), Director, Silk Printing Mill (Shanghai) No.7

- Jin Fu (Ms.), Shanghai Research Institute of Silk Technology.

III. HANGZHOU

- Zhou Wen, Zhejiang Provincial Science and Technology Commission.
- Liang Yuan Xia, Director, Industrial Section, Zhejiang Provincial Science and Technology Commission.
- Zhu An Li, Project Manager, Zhejiang Provincial Science and Technology Commission, International Cooperation Section.
- Ma Jia-Xiou, Chief Engineer, China National Silk Import and Export Corporation, Zhejiang Branch.
- Tan Zhong Dong, Director, Hangzhou Silk Printing and Dyeing Mill.
- Xu Zhao Zhi, Vice Chief Engineer, Hangzhou Silk Printing and Dyeing Mill.
- He Zhi-jun, Professor of Computer Science and Engineering, Zhejiang University.
- Yu Tao, President, Zhejiang Silk Research Institute.
- Ling Meng Li, Vice President, Zhejiang Silk Research Institute.

ANNEX II

DATA REQUIREMENTS FOR A SOCIOECONOMIC ANALYSIS OF THE CHINESE SILK INDUSTRY

i. Total Employment (for different years)

- By occupation
- By sex
- By small and large enterprises.

ii. Total Output (Gross and net)

- By large and small enterprises
- By rural and urban areas
- By types of fabrics.

iii. Investment

- Total investment over different time periods
- Total investment by large and small enterprises
- Total capital and fixed capital per worker in:

  a) cotton textiles, b) woollen textiles and, c) silk textiles.

iv. Consumer Expenditure in Rural and Urban Areas

- Rural expenditure on:

  a) cotton textiles
  b) woollen textiles
  c) silk textiles/garments

- Urban expenditure on cotton, woollen and silk textiles and garments.

v. Rates of Machine Utilisation in Silk

  a) dyeing
  b) printing
  c) finishing

vi. Labour Input by Different Types of Equipment

vii. Growth of Exports of:

  a) raw silk
  b) silks and satins
  c) silk fabrics

viii. Productivity of Labour in Different Production Processes

ANNEX III

BASIC ECONOMIC DATA AVAILABLE ON THE CHINESE SILK INDUSTRY

TABLE 1

ANNUAL OUTPUT AND EXPORTS OF CHINESE SILK (1949 - 1990)

Year	Output of Silk Cocoons (000 tons)		Output of Silk		Exports of Silk	
	Mulberry Cocoon	Tussah Cocoon	Silk (000 tons)	Silk fabrics (million metres)	Raw Silk (000 tons)	Silk and Satins (million metres)
1949	31	12	1.8	50	1.5	8.21[1]
1952	-	-	5.6	-	2.0	17.4
1957	-	-	9.9	-	3.2	54.5
1962	-	-	4.7	-	0.9	130.8
1965	-	-	9.1	-	2.8	95.0
1970	122	43	16.7	432	4.3	84.2
1975	-	-	23.1	-	4.8	116.2
1980	250	76	35.4	759	7.7	132.2
1981	252	59	37.4	835	-	-
1982	271	43	37.1	914	-	-
1983	268	72	36.9	999	-	-
1984	306	50	37.6	1,178	-	-
1985	336	35	42.2	1,449	10.4	144.0
1986	296	20	47.0	1,500	8.9	170.0
1990 (target)	380	50	49.0	1,700	10.0	200.0

Sources: Statistical Yearbook of China, 1986; and data supplied by the Bureau of National Silk Corporation.

1 - for 1950

TABLE 2

PHYSICAL OUTPUT OF SILK BY KEY PROVINCES (1985)

Province	Output (tons)
National Total	42,199
Zhejiang	12,156
Sichuan	11,143
Jiangsu	8,562
Guangdong	2,549
Liaoning	2,270
Shandong	1,697
Shanghai	934
Anbui	740

Source: Statistical Yearbook of China, 1986.

TABLE 3

VALUE OF GROSS INDUSTRIAL OUTPUT OF TEXTILE INDUSTRY (1985)
(Rmb 100 million at current prices)

Sector	Total Value		Percentage of industrial total	
	(1980)	(1985)	(1980)	(1985)
Textile industry	735.5	1273.2	14.7	15.3
Of which:				
Cotton textiles	499.5	657.5	9.0	7.9
Silk textiles	54.3	111.5	1.1	1.3

Source: Statistical Yearbook of China, 1986.

TABLE 4

VALUE OF NET INDUSTRIAL OUTPUT OF TEXTILE INDUSTRY (1985)
(Rmb 100 million at current prices)

Sector	Total Value		Percentages	
	(1980)	(1985)	(1980)	(1985)
Textiles	214.58	285.42	13.0	10.3
Of which:				
Cotton textiles	132.70	136.92	8.1	4.9
Silk textiles	14.42	26.57	0.9	1.0

Source: Ibid

TABLE 5

INVESTMENT IN CAPITAL CONSTRUCTION (1985)
(Rmb 100 million)

Item	Textile industry	Cotton textiles	Silk textiles
Total investment	12.61	4.97	1.15
Productive construction	8.79	3.50	0.67
Non-productive construction	3.82	1.47	0.48
Residential buildings	2.74	1.06	0.37
New construction	6.32	2.73	0.58
Expansion	3.64	1.23	0.91
Reconstruction	2.22	0.91	0.24

Source: Statistical Yearbook of China, 1986.

TABLE 6

PROJECTS UNDER CONSTRUCTION OR COMPLETED (1985)

Item / Sector	Textiles total	Cotton	Silk
Projects under construction (No)	845	350	180
No. of projects completed (No)	364	150	83
Completion Rate (%)	43.1	42.9	46.1
New fixed assets (Rmb 100 million)	9.43	3.91	0.59
Rate of utilisation of fixed assets (%)	74.8	78.7	51.3

Source: ibid

TABLE 7

OTHER CHARACTERISTICS OF SILK TEXTILES

Item	No. of industrial enterprises			Percentages	
	(1980)	(1984)	(1985)	(1980)	(1985)
Textile industry (000)	15.3	19.7	22.0	4.1	4.7
Silk textiles	1.6	2.1	2.7	0.4	0.6
	(1957)	(1965)	(1978)	(1984)	
Silk reeling machines (000)	30.9	26.7	45.4	98.4	
Mulberry cocoons (000)	205.6	265.2	722.3	1238.0	
Tussah cocoons (000)	-	35.5	68.6	73.4	

Source: Statistical Yearbook of China, 1986

ANNEX IV

TECHNICAL DATA ON SILK FACTORIES AND INSTITUTIONS VISITED IN CHINA

1. Shanghai Silk Printing Factory No.7

It is a medium-sized silk dyeing and printing factory with over 600 employees and a production of around 2.5 million metres per annum (average production for the past 9 years has been 3.1 million metres per annum) of woven silk fabrics, nearly all of which is printed.

There are 10 designers making about 2,000 designs a year, 60% of which are customers' designs. The average number of colours is 5-6, usually not more than 10. Exceptionally 16-colour designs may also be produced. Each design is made normally in five colourways.

The technical level of the factory is rather varied. There are a number of hand-printing tables, but there is also a microprocessor-controlled printing carriage (VIERO SIGMA 120). Silk is dyed on traditional (square) frames and conventional jiggers, but one of the jiggers (MEZZERA) is automatic, and another one (ASISA) runs under microprocessor control. The rest of the machinery is of average age and performance: continuous washing machines, SPEROTTO-RIMAR vibration-conveyor steamer for relaxing, ARIOLI steamer, etc.

Production lots are short at around 500 yard/design/colour-way; delivery time is 1-2 months. The factory claims to have the top level of printed silk production in China. This assertion is supported by the high quality of the products we saw in this factory as compared to the average quality seen elsewhere.

A new plant is under construction (11.8 million Yuan, out of which 1.2 million US$ foreign currency), with a planned area of nearly 10,000 square metres. New machinery will include automatic step-and-repeat machine (LUSCHER) and automatic flat screen printing machine (BUSER).

The factory has already started computer applications in the following fields:

Computer-Aided Design (CAD)

A CAD system has been developed in a joint project of Shanghai Silk Printing Factory No.7 with the Silk Printing Factory No.10, Jiao Tong University, Shanghai Mechanic and Electrical Design Institute and Shanghai Optical Instrument Factory, No.3.

The system consists of central computer, additional PC, monitors, scanner and laser exposure device.

The central computer is a very advanced DEC MicroVAX II minicomputer with Digital Graphics Systems, Inc. graphics processor, and a 512*512 resolution colour monitor. It is connected to a PC-driven high resolution (1024*1024) monitor as well.

The scanner is a Photoelectric Colour Separating Scanner, Model FS II., manufactured by the Optical Instrument Factory and the University. The resolution is fairly low, 6.5 lines/mm, about ½ to 1/3 of what is required for this kind of work. Scanning speed is 240 lines/min. which is acceptable.

The laser exposure unit (also manufactured by the Optical Instrument Factory and the University) is capable of transferring the design from the computer onto photosensitive film, thus producing colour separations.

The accuracy of the system - primarily due to the low performance of the peripheral devices - is said to be below the desired level. It is not reliable enough, and not yet suitable for production purposes. The aim of the project was said to be an exercise (in order to get first-hand information on such systems) rather than the manufacturing of a production unit.

Computer Colour Matching (CCM)

The factory has installed an Applied Colour Systems (ACS) colour matching system, consisting of a SpectroSensor II, spectrophotometer and a DEC PDP 11-23+ minicomputer. This system (coming from one of the leading manufacturers in the field) represents the state-of-the-art. Its operation has only recently begun, and the staff was said to be still in the process of receiving training. It was emphasized that information and training would be needed for the full utilization of the capabilities of CCM.

Microprocessor-based process controllers

As mentioned above, there are two process-controlled production machines in the factory: the VIERO printing carriage and the ASISA jigger. There was no time to discuss in detail the experiences of the factory with these machines, but it was stated that the first results in printing were very good, and the repeatability and overall quality of printing was much improved as compared to conventional hand-printing. The productivity (per table) is significantly increased.

Due to the relatively low technical level of existing conventional machinery, retrofitting does not seem feasible. New machines - particularly printing carriages - should be considered to be purchased with microprocessor control.

In management some PCs are already used, and this appears to be a field where the factory can systematically progress towards more and more complex systems with relatively little external assistance.

The management of this dynamic and growing factory, (where the quality of the production is higher than that expected given the present technical possibilities) seems determined to introduce advanced CAD/CAM techniques, which is of course one of the most important preconditions for development at this level.

2. Hangzhou Silk Printing and Dyeing Complex

This is the biggest silk factory complex in China, covering an area of 320,000 sq. metres, with 5,800 employees and an annual production of 150 tons of raw silk, 12 million metres of silk fabrics and 40 million metres of dyed and printed silk piece goods.

Reeling is performed in the conventional way: some of the reeling machines are imported, but there are also locally developed machines. Some of the 700 weaving looms are Japanese; others are Chinese origin. Conventional hand-printing tables and BUSER screen printing machines are used. Reeling is made in two shifts, dyeing and printing in three shifts (both six days a week), weaving is four shifts or round the clock. Fifty-two per cent of the pure silk production is exported. The quality of silk however appeared to be below that of the Shangai Silk Factory No.7.

3. Hangzhou Silk Dyeing and Printing Factory

It is a medium-size factory with 1,000 employees and an annual production of 12 million metres. Ninety-five per cent of the production is pure silk, 80% of which is sold bleached. The two million metres of dyed and printed fabric is sold mainly in the domestic market.

Printing machinery consists of a large number of hand-printing tables, but there are also very modern screen-printing machines (BUSER) with fairly advanced automation. The rest of the machinery appeared to be average.

This factory (like the Shanghai Silk Printing Factory No. 7) has also started to introduce CAD/CAM in a number of fields.

Computer-aided design

In cooperation with the Zhejiang Silk Research Institute in Hangzhou the mill has developed a CAD system for the production of jacquard cards (see below). This is another experimental unit (like the one in Shanghai), not yet suitable for production purposes.

An ACS colour matching system, identical to the one in the Shanghai Silk Factory No. 7 has recently been installed. Utilization is also very similar: there is very little experience in the use of this method, and external help would be needed in the form of training and consultancy services.

Management

Personal computers (PCs) are used for accountancy and other simpler tasks; complex management decision support systems have not yet been considered. The management seems genuinely interested in the application of computers.

4. Zhejiang Silk Research Institute, Hangzhou

The institute has a wide variety of standard textile laboratory equipment; also some special instruments, some of which are highly sophisticated and represent the state-of-the-art. The following pieces of equipment were shown: Transmission spectrophotometer (SHIMADZU), Thin Layer Chromatograph (SHIMADZU), laboratory Pad-Roll dyeing machine (ARTOS), lab. stenter (BENZ), lab dyeing machine (PRETEMA), amino acid analyzer (HITACHI).

Of special interest was the CAD/CAM system jointly developed with the Silk Printing and Dyeing Factory. The system consists of a scanner: full colour (RGB) read-in of 15 colours at one scanning, with a resolution of 0.1 mm. This resolution is adequate for most applications in jacquard weaving. The scanner is connected to a Cromemco Z2H graphics computer with colour monitor. The output is to a jacquard card punch (also developed in China) which produces cards directly applicable on a weaving machine. It was emphasized, that the system was experimental, and had been developed primarily for educational purposes.