OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

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

D03696

Distr.
LIMITED

ID/WG.128/6
12 May 1972

ORIGINAL: ENGLISH

United Nations Industrial Development Organization

Expert Group Meeting on New Techniques
or Yarn and Fabric Production

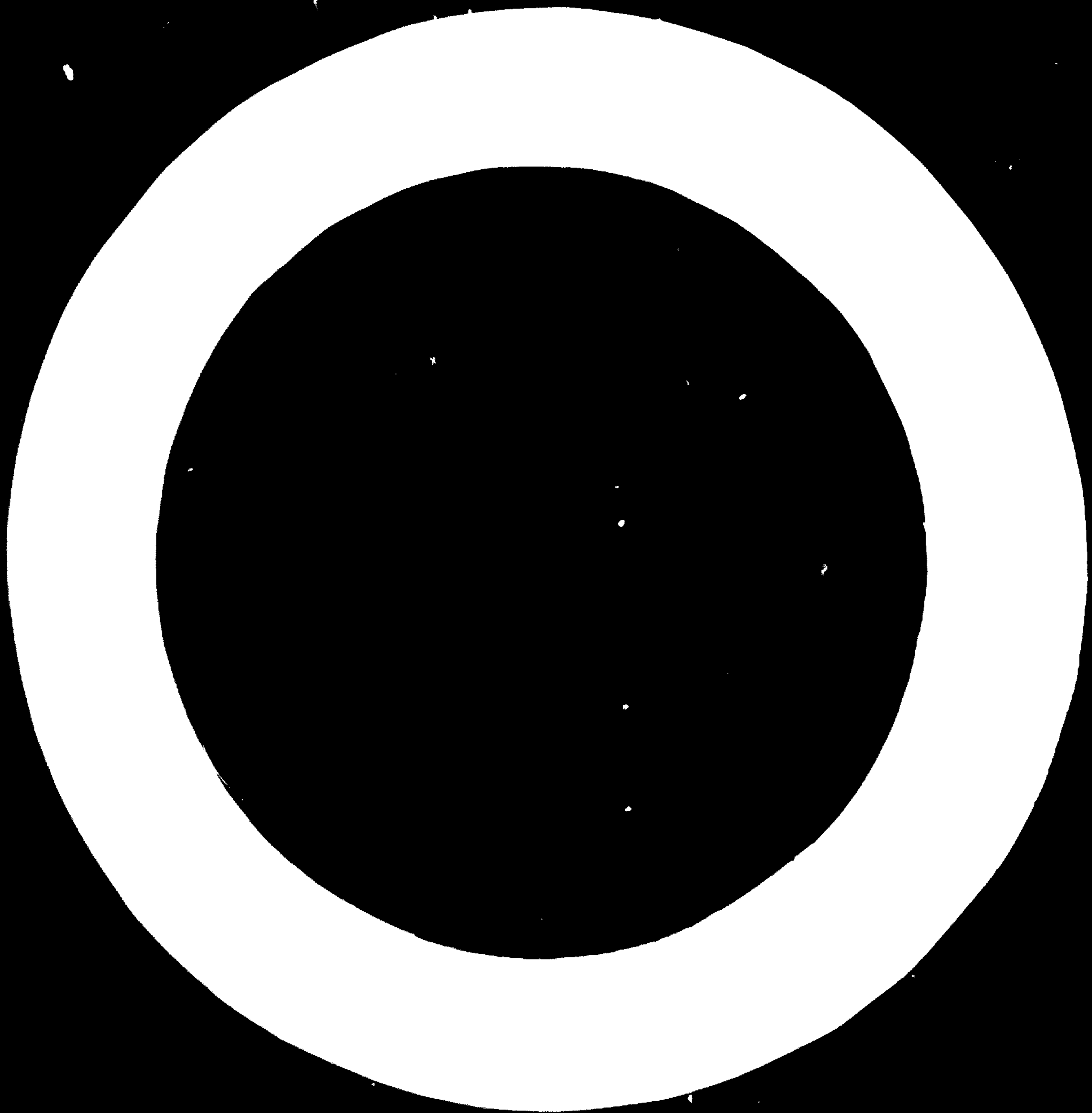
Manchester, United Kingdom, 19 - 22 June 1972

PROSPECTS OF OPEN-END SPINNING IN INDIA

by

K. Sreenivasan
Director of the South India Textile Research
Association, Coimbatore, India

1 The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the Secretariat of UNIDO. This document has been reproduced without formal editing.



PROSPECTS OF OPEN-END SPINNING IN INDIA

1. Introduction

Adoption of major technological changes in the industries of developing nations poses a number of socio-economic problems apart from those created by the technology itself. Shortage of capital resources, lack of indigeneous equipment, problems of maintenance, fear of the resulting unemployment, are all inhibiting factors that retard the introduction of sophisticated technology. To give a few examples from the textile industry itself, though the advantages of introducing automatic looms in terms of cost reduction have been well known for a long time, their introduction in India has been extremely slow. The number of automatic looms is only about 18% of the total and the rate of increase during the past 15 years is less than 1% a year. Similarly, the advantages of high production carding have been well known for nearly a decade and yet there are very few high production cards in India. Only a small percentage of cards have been converted to semi-high production carding. Therefore, one should be extremely careful in forecasting the rate of introduction of such a revolutionary development as open-end spinning.

On the other hand, there are always some units which are technologically advanced and financially strong and would like to experiment with new developments and study their working on the basis of first-hand information. As leaders of industry in their country, having and using the latest equipment is not only a matter of economics, but a question of status for them. In considering the future prospects of open-end spinning in India, these factors should be borne in mind.

Apart from these inhibitive factors that slow down the process of change, the effect of changing technology on the economics of an industry is an area of considerable importance. In a country where labour is abundant and can easily be trained and where wages are low in comparison with affluent societies, the economic compulsions of cost are somewhat different from countries with labour shortage and high wages. In such a situation, investment in sophisticated technology is not always economical.

2. Literature Survey

The economics of open-end spinning have been studied by a number of research workers. In most of the studies[1,2,3] the rotor speed has been assumed to be constant at 30,000 rpm.

Catling[4] has reported that 50,000 rpm. would be the optimum speed for all counts from the point of view of overall cost. He has found that the curve relating speed and cost is flat in the region of optimum speeds, and consequently the incentive to developments leading to much higher speed is not great.

Smith and Lord[5] have studied the effect of drum speed and drum diameter on costs. They have concluded that in the future, labour cost will probably increase and machine cost will fall. Both trends will reduce the optimum speeds at which the machines should be run; it is likely therefore that in the future, machines will be run at speeds less than those technologically possible.

The studies reported so far compare only the cost of production; the fact that the capital investment, for the same volume of production, would be much higher in the case of open-end spinning and consequently the return on capital would be lower has not been taken into account. Further, the studies generally assume certain specific values for costs and do not bring out the relationship between optimum speed, capital cost, life, power cost, etc.

3. <u>Economics</u>

For the purpose of evaluating the economics of open-end spinning, the following factors have been considered.

1. The capital investment for a given production.
2. Optimum speed for minimum cost.
3. Optimum speed for maximum return.
4. A comparison of the cost of production with ring spinning.
5. A comparison of return on investment with ring spinning.

In making such an evaluation, there are a number of handicaps because of the non-availability of some basic technological information. For example, will the raw material cost be higher or lower than ring spinning for equivalent fabrics? Or, what is the increase in the cost of open-end spinning machines as the rotor speed increases? How long does it take to effect a piecing on open-end spinning machines? Are the end breaks likely to increase with increase in speed? What is the order of maintenance and replacement costs? In the absence of answers to such questions, one is forced to make certain assumptions and the accuracy of one's conclusions will largely depend on the validity of the assumptions.

The following broad assumptions have been made:

1. The capital cost per drum will be the same irrespective of the rotor speeds.

2. Power costs will increase as the square of the rotor speed.

3. Labour cost per unit production would be the same for all speeds.

4. There will be no change in raw material and maintenance costs from ring spinning.

3.9. Capital Investment for a Given Production

In a developing country like India where there is a shortage of capital resources, even if the economic advantages of cost are overwhelming, the investment in new technology may not be made if adequate capital is not available. Table 1 gives the comparative capital investment for producing yarn equivalent to that from one ring spinning spindle.

Table 1

Capital Investment for Producing Yarn Equivalent to that from one Ring Spinning Spindle

Count	Open-end spinning				Ring spinning
	10s	20s	30s	40s	
Investment ($)	77.5	50.4	51.0	50.6	16.5

The capital required is (Table 1) 150 to 100% more in the case of open-end spinning, and not many mills in India can afford investment of that order. Unless the price of open-end spinning machines comes down in the near future, the initial investment alone may act as a major inhibitive factor.

3.2. Optimum Speed for Minimum Cost

The economics of open-end spinning would depend on the rotor speed. An increase in rotor speed would reduce the capital cost for unit production in proportion to the increase in speed. On the other hand, power costs for unit production would increase in proportion to the speed. Optimum speed therefore would be that speed for which the sum of these two costs is a minimum.

The expression for arriving at the optimum speed is given in Appendix 1*. From the expression, it is clear that the optimum speed is that speed at which the net annual capital charges are equal to the power cost for the year. The optimum speeds are not affected by the counts spun since they are only governed by the annual capital charges and the power cost.

---

* The author is indebted to Shri T.V.Ratnam, Asst.Director, SITRA, for the formulae in Appendix 1 and 2 .

FIG.1 : OPTIMUM SPEED FOR MINIMUM COST

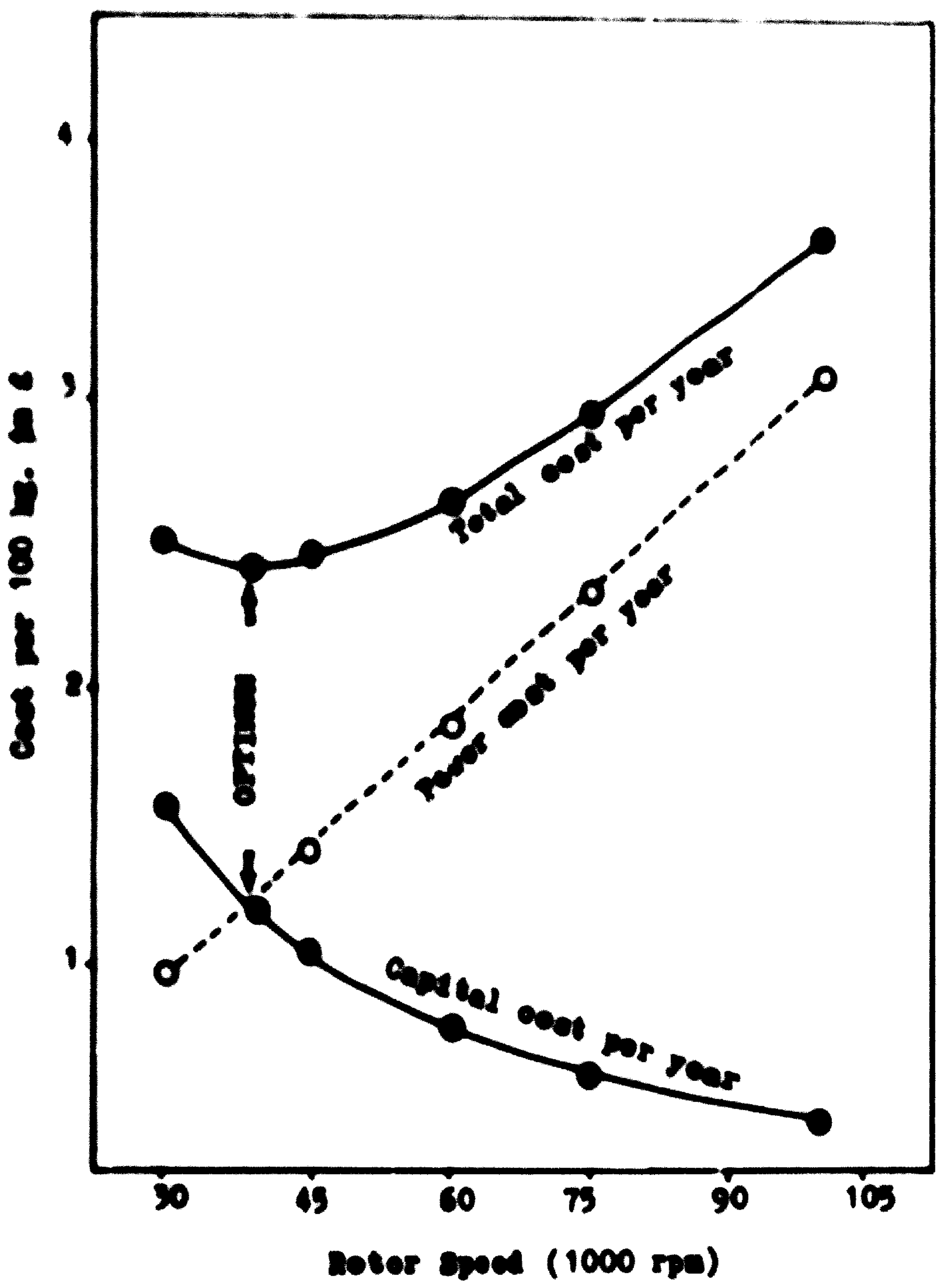


Figure 1 gives the total cost for 100 kg. of 20s yarn for a machine life of fifteen years and three-shift working. It is found that the optimum speed for minimum cost is about 38,800 rpm.

However, if the machine life increases, because of a net reduction in the annual capital charges, the optimum speeds are found to be lower. This is indicated in Table 2.

Table 2

Optimum Speed for Different Years of Life

Life (years)	Capital investment after tax concessions (£)	Present worth of salvage value (£)	Net capital investment (£)	Annual capital charges per year (£)	Annual capital charges / power cost * (a)	Optimum rotor speed : (a) x 30,000 (rpm)
10	59.3	11.4	47.9	7.8	1.400	42,000
15	57.8	7.1	50.7	6.7	1.294	38,800
20	57.4	4.4	53.0	6.2	1.251	37,500
25	57.4	2.7	54.7	6.0	1.231	36,900

* About £ 4 per drum per year.

However, it is found that though the optimum speed decreases as the machine life increases, it is not very sensitive, particularly for a life beyond 15 years.

The extent to which the speed of the machine would affect the capital and power costs as well as capital investment is more important than considering optimum speed alone. This is indicated in Table 3.

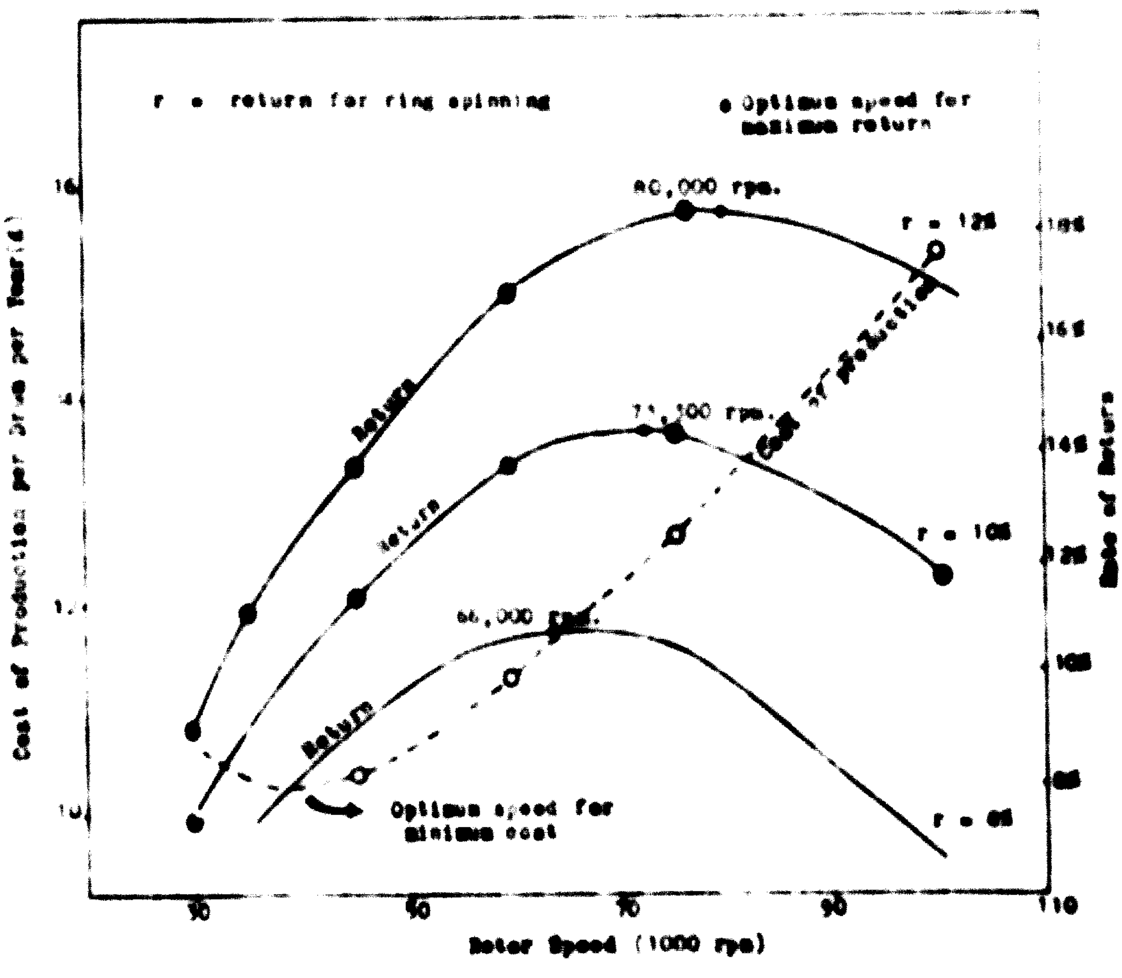
Table 3

Cost of Production per Year (For a Production Equivalent to 10,000 drums operating at 30,000 rpm)

Rotor speed (rpm)	As differences from corresponding figures for 30,000 rpm.	
	Capital investment	Operating costs
	(in thousand £)	
36,000	197	-3.2
38,800 (optimum)	269	-3.5
40,000	296	-3.4
45,000	395	-2.3
50,000	474	-0.2
60,000	592	6.5
75,000	711	20.7
1,00,000	829	46.2

Negative sign means that the operating costs are lower than that for 30,000 rpm.

FIG. 2 : OPTIMUM SPEED FOR MAXIMUM RETURN &



It can be seen that over a range of speed from 30,000 to 50,000 rpm. there is little change in operating costs.

5.3. Optimum Speed for Maximum Return

The speed at which the cost is minimum need not necessarily yield the highest return on investment. This is because speeds higher than the optimum for which the cost is minimum have the advantage of lower capital investment for unit production. It is quite possible that this lower capital investment may more than offset the increase in the cost of production and consequently, the return on investment would be higher. This would depend on the rate of return prevailing in any given mill. The optimum speed for maximum return would obviously be higher than the optimum speed for minimum cost, for any speed lower than the latter would mean not only that costs are higher but also the capital is greater and consequently, the return would be lower.

The expression for arriving at the optimum speed from the point of view of return is given in Appendix 2. A comparison of cost as well as return on capital for different levels of speeds is shown in Figure 2 for a fifteen year life and for three different levels of return for ring spinning.

It can be seen that the optimum speed for minimum cost is about 39,000 rpm. For a return of 10% at optimum speed for minimum cost, the optimum speed for maximum return is 73,300 rpm.

3.4. Comparison of the Cost of Production

In comparing the cost of production between open-end spinning and ring spinning, only those items of cost which are affected have been taken into account. In estimating ring spinning costs, conditions existing in high productivity mills in India have been taken into consideration. A rotor speed of 30,000 rpm. has been assumed. The cost per drum of open-end spinning has been taken to be about £120 and the cost per ring spindle about £15. In the case of an existing mill, the fly frames and the winding machines would be rendered surplus; the resale value of these machines has been deducted from the capital cost of open-end spinning. For a new mill, the cost of new fly frames and winding machines has been added to the cost of ring frames. The machine life has been assumed to be 15 years for three-shift working and allowances have been provided for tax concessions for depreciation as permitted in India. The cost differences for the two systems are compared in Table 4. The cost figures have been given in terms of a ring spinning spindle in order to facilitate comparison between counts also.

Table 4

Cost of Producing Yarn Equivalent to that from one Ring Spinning Spindle - Existing Mill
(£ per spindle per year)

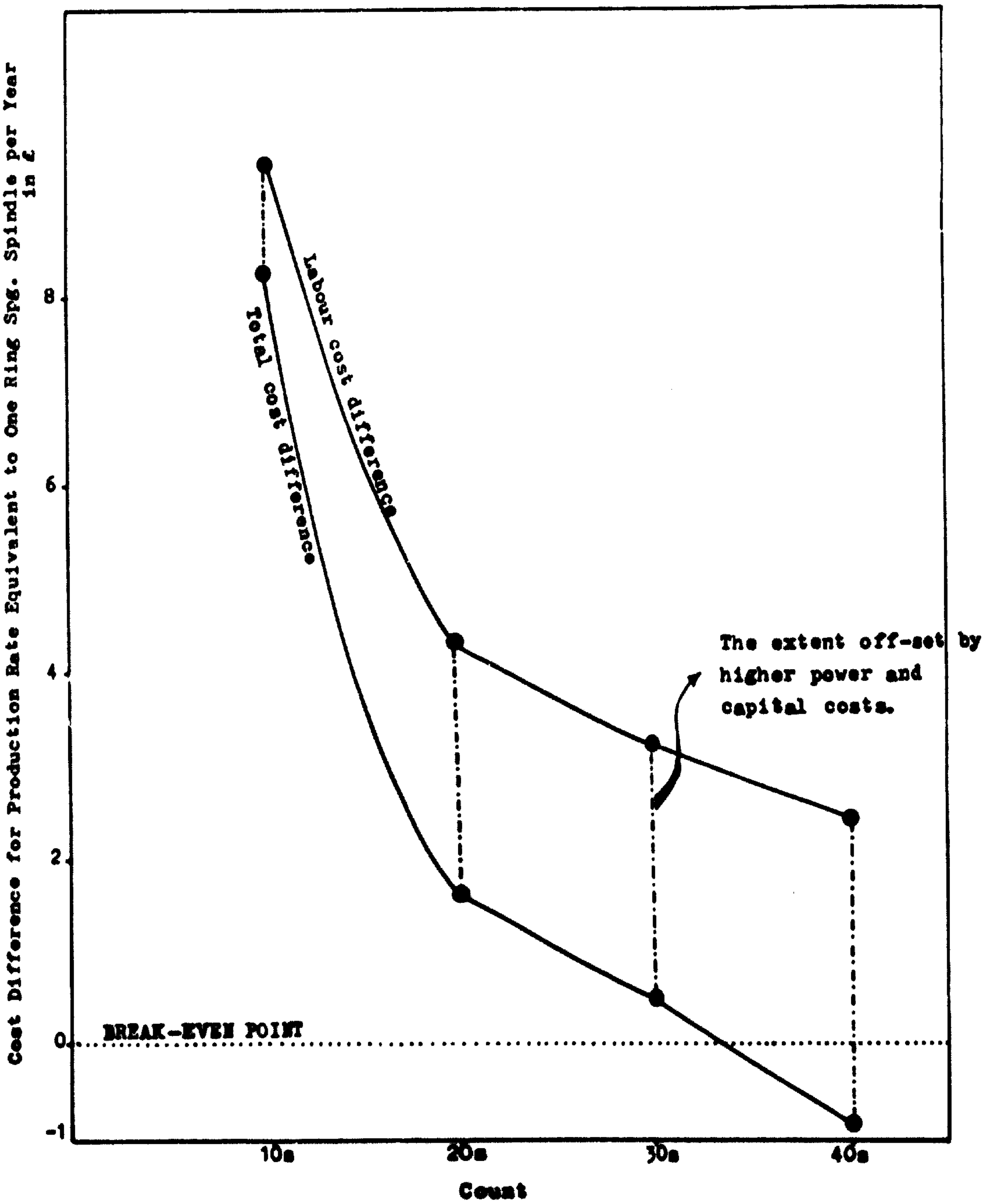
Count	10s		20s		30s		40s	
	O.E.	R.S.	O.E.	R.S.	O.E.	R.S.	O.E.	R.S.
Capital cost	2.1	0.8	2.8	0.8	2.9	0.8	3.2	0.8
Labour cost	2.6	12.0	1.8	6.0	1.2	4.4	1.1	3.4
Power cost	1.3	1.0	1.7	1.1	1.8	1.0	1.9	0.9
Excess waste	-	0.4	-	0.3	-	0.2	-	0.1
Total	6.0	14.2	6.3	8.2	5.9	6.4	6.2	5.2

O.E. : Open-end spinning R.S. : Ring spinning

Open-end spinning is very economical in 10s count, the cost being lower by about £ 8 per spindle per year. The difference between the two is considerably narrowed in 20s count to about £ 2 per spindle and almost disappears in 30s being only £ 0.5 per year. In 40s count, the costs are higher by about £ 1 per spindle per annum.

The significant advantage in 10s count in open-end spinning is mainly due to the large reduction in labour cost

FIG. 3 : DIFFERENCE IN COST PER SPINDLE BETWEEN OPEN-END SPINNING AND RING SPINNING



when compared to ring spinning. The number of workers for a 25,000 spindle mill for three-shift working is reduced by 996, while in the case of 40s count this reduction is only of the order of 254 workers. Apart from the reduction in the number of workers in the case of 10s count, the spindle speeds are also very much lower at 9000 rpm. when compared to 40s while in the case of open-end spinning, same rotor speeds have been assumed for all counts. On the other hand, there is a progressive increase in capital and power charges for open-end spinning as the count becomes finer and this factor more than offsets the reduced savings in labour cost in 40s count. This is illustrated in Figure 3.

Instead of 30,000 rpm. rotor speed, if the optimum speed for minimum cost of 38800 rpm. is taken, then the cost difference between ring spinning and open-end spinning remains practically the same (Table 5). The additional investment is lower by 30 to 37%.

Table 5

Comparative Costs for Optimum Speed (Minimum Cost) of 38,800 rpm. (per spindle per year)

Count	10s	20s	30s	40s
Additional investment (£)	14.5	24.5	25.0	[illegible]
Savings in cost per year (£)	8.1	1.7	0.35	-1.1

In case a new mill is being considered, the cost for ring spinning would increase because of the additional cost of new fly frames and cone winding machines while the labour cost in fly frames and cone winding machines would be reduced slightly. The cost for open-end spinning would be practically the same. The comparative figures for a new mill are given in Table 6.

Table 6

Cost of Producing Yarn Equivalent to that from One
Ring Spinning Spindle - New Mill
(£ per spindle per year)

Count	10s		20s		[illegible]0s		[illegible]	
	O.E.	R.S.	O.E.	R.S.	O.E.	[illegible]	[illegible]	[illegible]
Capital cost	2.2	1.5	2.9	1.1	2.9	1.1	[illegible]	[illegible]
Labour cost	2.6	10.9	1.8	5.5	1.2	4.0	[illegible]	[illegible]
Power cost	1.3	1.0	1.7	1.1	1.8	1.0	[illegible]	[illegible]
Excess waste	-	0.4	-	0.2	-	[illegible]	[illegible]	[illegible]
Total cost	6.1	13.8	6.4	7.9	5.9	[illegible]	[illegible]	[illegible]

O.E. : Open-end spinning   R.S. : Ring spinning

While the conclusions arrived at in the case of an existing mill seem to apply in this case also, the savings to open-end spinning are somewhat lower.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

[illegible] the rate of return is the same for both [illegible].

[illegible] of the rate [illegible] investment per spindle, if the rate of return for the same investment [illegible] is compared, the result is almost the same. [illegible] open end spinning is highly profitable only in [illegible] count, [illegible] does not yield as high a return as ring spinning.

If the return on investment is considered [illegible] rpm. for [illegible] return, then open end spinning would be economical for [illegible] count also (Table [illegible]).

It can be seen from the Table that at a [illegible] return on the rotor speed of [illegible] rpm, the return at [illegible] rpm. is [illegible] in the count as against [illegible] in ring spinning.

Table 8

Comparative Returns Between Open-end Spinning and Ring Spinning

Count	20s	30s	40s
Open-end spinning		per cent	
i. 30,000 rpm.	[illegible]	7.5	7.5
ii. 35,000 rpm. (optimum speed for minimum cost)	10.0	10.0	10.0
iii. 45,000 rpm. (optimum speed for maximum return)	14.4	14.4	14.4
Ring spinning	17.9	22.0	14.7

6. Future Prospects

From what has been considered so far, it is obvious that under the present circumstances, though the cost of production in open-end spinning is lower than ring spinning upto 30s count, from the point of view of return on investment, it is not economical beyond 16s. The question naturally arises as to what are the conditions under which open-end spinning would be economical for counts beyond 16s. Table 9 gives the conditions under which open-end spinning would yield a 10% return after capital recovery and interest charges.

Table 9

Conditions Under Which Open-end Spinning Would Yield a Return of 10%

20s count	30s count	40s count
i) Rotor speed of 45,000 rpm.	i) 25% lower capital cost & rotor speed of 45,000 rpm.	40% increase in wages
or	or	and
ii) 25% lower capital cost & rotor speed of 30,000 rpm.	ii) 25% lower power cost & rotor speed of 60,000 rpm.	i) 35% lower capital cost & rotor speed of 45,000 rpm.
or	or	or
iii) 25% lower power cost & rotor speed of 40,000 rpm.	iii) 40% increase in wages & rotor speed of 48,000 rpm.	ii) 35% lower power cost & rotor speed of 70,000 rpm.
or		
iv) 40% increase in wages		

From the above table, it is obvious that if the machine cost could be lowered or if the power cost could be reduced, the machine could become economical for counts upto 30s. It is also evident that from the point of view of the economics of the Indian Textile Industry, it seems to be more important to reduce machine and power costs than to aim for very high speeds. Wages in India are expected to go up by about 40% in the next seven years. If this happens, then open-end spinning would become economical upto 20s. If at the same time, machine speed could be increased to 48,000 rpm, then its economic use could be extended upto 30s.

There are at present about 1.5 million spindles in the country between the count range 10s - 20s. This is probably spread over 350 mills. Most of these mills will not be in a position to make the necessary investment. The chances are perhaps a third of them will buy one or more open-end spinning machines depending on their financial resources and technical competence. Therefore, I expect that during the next 5 years, assuming that the open-end spinning machines will be manufactured within the country, about a maximum of 250 machines are likely to be installed in about 100 mills.

Another factor that has not been considered in working out the economics of open-end spinning is the compensation that would have to be paid to the workers who might be rendered surplus as a result of its introduction. Apart from the difficulty of retrenching workers in India, the compensation that has to be paid is a fairly heavy burden which depends on a number of factors and is difficult to estimate beforehand. This would also be an inhibiting factor for mills who wish to install open-end spinning machines on a large scale.

The last but certainly not the least important factor that should be considered is whether open-end spinning machines are likely to be made in India in the near future. The Indian Government does not permit the free import of machines. While a few machines may be permitted for purposes of demonstration or evaluation, large-scale imports are not likely to be allowed. Therefore, a pre-requisite for the large-scale introduction of open-end spinning machines would be manufacture within the country either independently or under collaboration with a foreign manufacturer.

Appendix 1

Expression for Optimum Speeds

An expression for optimum speed has been derived on the following assumptions.

i) The price per drum is constant irrespective of the rotor speeds.

ii) Production rate increases directly in proportion to rotor speeds.

iii) Power consumption and hence power costs increase as the square of the rotor speeds.

iv) The power rates remain unchanged over the life span of the machine.

v) The labour cost per unit production in open-end spinning would be the same for all speeds.

vi) Changes in cost due to saving in space have not been taken into account.

Effect of increasing the speed of the open-end machine would be to reduce the capital cost per unit production in proportion to the increase in speed. On the other hand, the power cost per unit production would increase in proportion to the speed. The optimum speed would therefore be that speed for which the sum of these two costs is a minimum.

<u>Symbols</u>

C - Capital cost of machine per drum.

d - Present worth of tax concessions on development rebate, depreciation and salvage value of machine expressed as a ratio of the investment C.

n - Life in years.

i - Interest rate (ratio).

s - Rotor speed (rpm).

p - Power cost per drum per year for speed 's'.

t - Tax rate.(ratio)

x - Extent of increase in speed from 's' as a ratio.

l - Capital recovery factor = $\frac{i(1 + i)^n}{(1 + i)^n - 1}$

T - Sum of capital cost and power cost per year.

The total cost of capital and power for the existing speed of 's' is

$$T_s = Cld + p \qquad (1)$$

and that for a speed of 'xs' is

$$T_{xs} = \frac{Cld}{x} + px \qquad (2)$$

Any difference of T_{xs} over T_s is subject to tax deduction or tax concession depending upon whether it is a saving or excess of cost. Hence, the net cost after adjusting for tax is :

$$\left(\frac{Cld}{x} + px \right) \quad (1 - t) + t\,(Cld + p) \;\ldots\ldots\ldots\ldots(3)$$

The above cost is minimum if,

$$x = \sqrt{\frac{Cld}{p}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

The factor 'Cld' is the annual capital charges after allowing for tax concession on development rebate and depreciation and salvage value of machine.

<u>Price of Machine Varying with the Speed</u>

If for every 1% increase in speed the cost increases by a %, then the cost of machine is

$$C + aC\,(x - 1) \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

The total cost is $\frac{Cld}{x} + \frac{aCld(x - 1)}{x} + px$

The above cost is minimum if

$$x = \sqrt{\frac{Cld\,(1 - a)}{p}} = \sqrt{(1 - a)}\,\sqrt{\frac{Cld}{p}} \;\ldots\ldots\ldots\ldots(6)$$

The expression (6) is the same as expression (4) except for the factor $\sqrt{(1 - a)}$.

It follows that the effect of increase in machine costs as speed increases would be to reduce the optimum speed, the extent of reduction depending on the amount of increase in costs.

To illustrate, if machine cost increases at the rate of 0.5% for every 1% increase in speed, then a = 0.5 and the optimum speed is $\sqrt{0.5}$ times (i.e. 0.707 times) the optimum speed for which the cost is assumed to be independent of speed.

Appendix 2

Optimum Speed for Maximum Return

The optimum speed for maximum return should be obviously higher than the optimum speed for minimum cost, for any speed lower than the latter would mean not only costs are higher but also the capital is greater and consequently the return is lower.

Let x_1s be the optimum speed for minimum cost.

Then $x_1 = \sqrt{\frac{Cld}{p}}$ (from expression 4)

If xs is the optimum speed for maximum return, then x [illegible] x_1

If r is the rate of return (over and above the annual capital charges) for capital investment of $\frac{C}{x_1}$, then

Return on capital for $\frac{C}{x_1} = \frac{C\,r}{x_1}$ .... [illegible]

Capital and power costs per year for $\frac{C}{x_1} = \frac{Cld}{x_1} + px_1$ .... [illegible]

Capital and power costs per year for $\frac{C}{x\,x_1} = \frac{Cld}{x\,x_1} + pxx_1$ ... [illegible]

Return on capital for $\frac{C}{x\,x_1} = \frac{Cr}{x_1} + \frac{Cld}{x_1} + px_1 - \frac{Cld}{xx_1} - pxx_1$ .. [illegible]

$$\therefore \text{Rate of return is } = \frac{x\,x_1}{C}\left\{\frac{Cr}{x_1} + \frac{Cld}{x_1} + px_1 - \frac{Cld}{xx_1} - pxx_1\right.$$

$$= xr + xld + \frac{p}{C}\,x_1^2\,x - ld - \frac{p\,x^2\,x_1^2}{C} \quad \ldots\ldots$$

The above is maximum, if

$$r + ld + ld - 2\,x\,ld = 0$$

$$x = 1 + \frac{r}{2ld}$$

Optimum speed for maximum return is = [illegible]

The optimum speed for maximum return is (1 + [illegible]) times that of minimum cost.

[illegible]

1. [illegible]

2. [illegible]

3. [illegible]

4. [illegible]

5. [illegible]

17. 6. 74