Utilization of Machine Tools in Bangladesh**

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ABSTRACT

The present trend towards higher productivity in almost all fields of engineering production has resulted in the invention of improved techniques of manufacturing and has brought about radical changes in the design of conventional machine tool structure.

In capital--shy developing countries like Bangladesh where there is acute shortage of foreign exchange, the production facilities, which are mostly imported, should necessarily be set for maximum possible utilization. In addition to the higher time utilization, the productivity can be enhanced through higher technological utilization. For example, if a seven feet lathe is predominently turning jobs less than one feet in length, then it has a poor technological utilization. Thus it is not alone sufficient to have universal machines with various accessories. These must be utilized to the maximum capacity.

Keeping this in view the production lathes in three different representative mechanical manufacturing factories were investigated. These factories work mostly in job and batch production.

This investigation has shown that most of the workers and the management are not well-aware of economic operation of a machine tool. The examples are economic cutting conditions, thread cutting, bed length etc. 81% of the jobs turned on lathes have dimensions 8" dia × 8" length or even smaller. The latheses are engaged for appx. 60% of their production time to manufacture these jobs.

On the basis of this investigation a new model of lathe has been suggested in this paper. App. 81% of the jobs can be manufactured on this type of lathe. The advantages of the model are :

1. *less material requirement for the construction of the machine tool,*
2. *simple, because there will be no lead screw and tail stock and the feed box design is simpler.*
3. *less space requirement,*
4. *lower price of the machine tool*
5. *finally higher productivity.*

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** *Data was collected by A.K.M. Masoom S. Hafeez and Q. M. Rahmna, all final year studetnts.*

1. Introduction :

Production facilities such as machine tools are very costly. If these highly capital-intensive machines have a poor utilization, the costs of products become high and consequently they become less competitive. Hence the management has a great responsibility to plan the production program and the investment in production facilities in such a way that they are utilized to the highest possible degree and thus most economic condition is attained.

There is a general misconception that it is sufficient to engage the production facilities for the maximum possible duration. As we shall see, it has serious drawbacks. For example. if a seven feet lathe is used all the time without interruption, one may say, it has the highest possibble utilization. But if the jobs machined are, say less than one foot, then the lathe has not been utilized to the maximum possible capacity. A much smaller lathe could as well have served the purpose and would have been more economic.

The problem of higher machine tool utilization is equally important for the rich and the poor countries. But it has a special economic and technological bearing for developing countries like Bangladesh. These countries are usually capital shy and have an acute shortage of foreign capital. Because most of the machine tools are to be imported, these countries must necessarily be quite aware of higher utilization of such production facilities.

2. Machine tool utilization and its definition

As it has been pointed out earlier, machine tools utilization can be divided into two groups: 1) Time utilization and (2) Technological utilization.

2.1. Time utilization (η_t) of a machine tool may thus be defined as that percent of its total available time, when it is direetly or indirectly engaged in production.

Total available time (T_A) may be defined from different aspects. For example it can be 8 hours in a shift or appx. 2000 hours per shift per annum. Any breakdown, repair or power failuie is not included in this time. (Direct or indirect) engaged time in production includes actual machining time (t_H), set-up time (tr), jobs and/or tool replacement time, time for quality checking, allowance etc. Thus this is the time, when the machine was actually engaged with different work-orders. Let it be known as T.

2.2. Technological utilization (η_{Tech})

While defining the utilization, it was said that a machine tool is utilized whenever it is directly or indirectly engaged in production. But during this time a machine tool may not be utilized to its maximum capacity, for example the case cited in introduction. The purpose of technological utilization will be to identify this lower utilization in capacitv.

It is quite difficult to define the technological utilizarion. mathematically. It will be tried to do so, with a number of factors which together influences the tech. utilization. These factors may be termed as

a. Manufacturing time utilization
b. Power capacity utilization
c. Space utilization
d. Utilization of different technological facilities of a machine tool
e. Accuarcy utilization,

a. Manufacturing time utilization,

A machine tool is actually utilized while the job is being machined. The remaining part of time utilization (which was defined section 2.1) includes also the non-productive time such as set-up time, allowance, quality control etc.

$$\eta_{tm} = \frac{t_H}{T} \qquad (1)$$

t_H= Actual operation time of a machine tool during time, T defined in section 2.1)

There is a lot of set practies to improve manufacturing time utilization, specially for machines where setup time is relatively high and/or where cutting speed is to be changed often. During one operation in the latter case, the spinale speed for the next operation can be pre-selected, so that the next operation can be started without any loss of time. In costly machines such as precision boring mills, where a lot of time is required to setup complicated jobs, the modern practice is to design the machine tool with two tables. While job is being operated on a table, the next job is clamped on the other table. This parallel activity improves the manufacturing time utilization.

b. Power capacity utilization.

If a machine tool is being run by a 3 HP electric motor and the operations on it require an average 0.5 HP, then a much smaller motor could have served the purpose and the machine tool would have been less costly.

$$\eta_p = \frac{Pav - P_{loss}}{P - P_{loss}} \quad (2)$$

η_P = power capacity utilization

P = installed capacity of the machine tool

Pav = average power requirement of the motor

P_{loss} = power loss in the motor

c. **Space Utilizations**

This problem was partly described in the introduction. Let us say, a lathe has 18 inch swing over cross slide. But on this machine the jobs turned during, say 80% of the time have diameter less than 6 inch. Consequently a smaller lathe could also serve the purpose for 80% of the time. Thus if the machine park of a factory consists of 10 lathes, 8 of them can easily have 6-8 inch swing instead of all having 18 inch swing.

Usually the management tries to justify the purchase of bigger lathes with the plea that it does not know the job spectrum of the future. Hence it is safer to purchase such a machine tool which can operate on all sizes of jobs. But with the help of modern forecasting techniques it is possible to predict the job specturm and thus plan for a balanced machine park.

d. **Utilization of different technological facilities of machine tools.**

A machine tool has different technological facilities, which are used for the manufacture of various products. These facilities are not the same for every machine tool. The examples are thread turning facility (lead screw system), thread chasing, thread whirling and taper turning attachment.

For example. if 80% of the jobs turned on lathes are not threaded, all the lathes are not required to have thread cutting mechanism, Thus a machine park consisting of 20 lathes can easily afford to have a similiar percent of simpler lathes having no thread cutting facility.

e. **Accuracy utilization**

It is well known that the cost of of production rises exponentially with the increase in accuracy. The accuracy of a machine tool usually should be ten times higher than that of a job being processed on it. As a result the machine tool itself become costlier. If the job spectrum is such that the machine tool is too accurate for the jobs then a less accurate and thus less costly machine tool could also serve the purpose. With a too accurate machine tool the accuracy utilization will be quite poor.

2.3. Overall efficiency of a machine tool.

The overall efficiency (η) of a machine tool depends on both time utilization as well as technological utilization

$$\eta = \eta_t \, \eta_{tech} \quad (3)$$

It has already been discussed that the technological utilization depends on five different aspects. It is quite difficult to measure all these five aspects, specially the last three aspects, namely space and accuracy utilization and utilization of technological facilities. These aspects have different output variables.

Taking time variable into consideration, technological utilization may be defined, though not very corrcctly,

$$\eta_{tceh} = \eta_{tm} \, \eta_p \quad \ldots(4)$$

2.4. General discussion on time and technological utilization

It is evident from the previous discussion that the utilization aspects, name time utilization, manufacturing time utilization, power capacity utilization can be measured for individnal machinesin a machine tool park. Thus the production program can be planned and controlled in such a way that the individual machine tools have higher utilization. Consequently this enhances the higher productivity in the factory. Power capacity utilization is also a problem of the machine tool designer.

Space and accuracy utilization and utilization of different technological facilities depends more on job spectrum. The example of the requirement of thread cutting mechanism on lathes may be cited here. These aspects are primarily problems of machine park and thus the investment policy of the machine tool user and the design policy of the machine tool manufacturer. We may here try to develop on information matrix, which shows the zone of influence of different utilization aspects.

	Machine tool user				Machine tool manufacturer		Machine tool	
Utilization aspect.	Production planning and control	Investment (including BMR)	Perso-nnel	Factory floor area	Production program	Design	individual	Park
Time util.	Y	Y	P	P	N	N	Y	N
Manuf. time util.	Y	Y	P	P	N	N	Y	N
Power capacity	Y	Y	N	N	Y	Y	Y	N
Space util.	Y	Y	N	Y	Y	Y	Y	Y
Tech facili.	Y	Y	Y	N	Y	Y	Y	Y
Accuracy util.	Y	Y	Y	N	Y	Y	Y	Y

Fig. 1. Information matrix showing the zone of influence of the different utilization aspects (Y=Yes; N=No, P=Partially)

2. 5. The responsibilities of the management and of the worker.

The management as well as the workers are greatly responsible for time utilization and manufacturing time utilization. The wage policy of the government also has a great influence.

The machine tool users and the manufacturers are interdependent in the whole system for higher machine tool utilization.

3. 0. Scope of this paper and the survey data.

The scope of this paper is primarily restricted to the determination of the space utilization and the utilization of the technological facilities in three representative factories in Bangladesh. They are engaged in job and batch production. Awareness of the management and of the workers about machine tool utilization will be ascertained. Such factors which influences the tool life will also be discussed here.

Forty production lathes were surveyed for appx. 600 machine hours. The included 113 different jobs for a total of 3844 products.

4. 0 Analysis of the data

4. 1. Job diameter

4.1.1. Frequency distribution of job diameter

Fig. 2. represents the absolute and the cumulitive frequency distribution of job diameter observed in these factories. Jobs upto 4 inch diameter represents 80% of the empirical distribution.

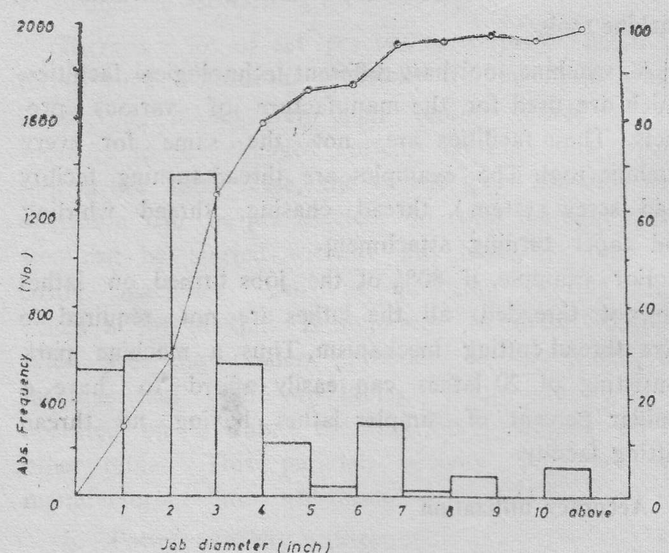

Fig. 2 : Frequency distribution of job diameter

4.1.2. Time capacity of job diameter.

Though absolute frequency of job diameter gives a representative picture of the job spectrum, but it does not at all reflect on the utilization of the machine. For example, the absolute frequency of a particular diameter range may be low, but it might take a long time to manufacture these jobs.

In contrast to Opitz [1] we shall use both type of frequency distributions, absolute frequency distribution for determining machine tool dimensions and time capacity for machine park.

Time capacity for a particular diameter class can found as follows:

$$T.C. = \Sigma (T_r + n.T_e)$$

T_r = Setup time for a lot
n = lot size

t_e = production time for a unit.

Fig. 3 shows the absolute and the cumulative time capacity of the observed job diameter. Jobs upto 8 inch diameter cover 80% of the capacity.

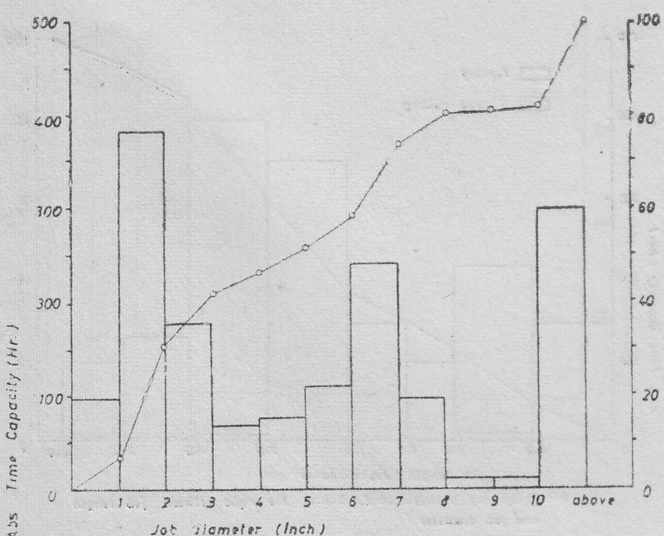

Fig. 3 : Frequency distribution (T.C.) of job diameter

4.2. The frequency distribution of d/D (d=job diameter, D=swing over bed)

4.2.1. Absolute frequency distribution.

Fig. 4 is the empirical distribution. Appx. 80% of the jobs have d/D into less than or equal to 0.3.

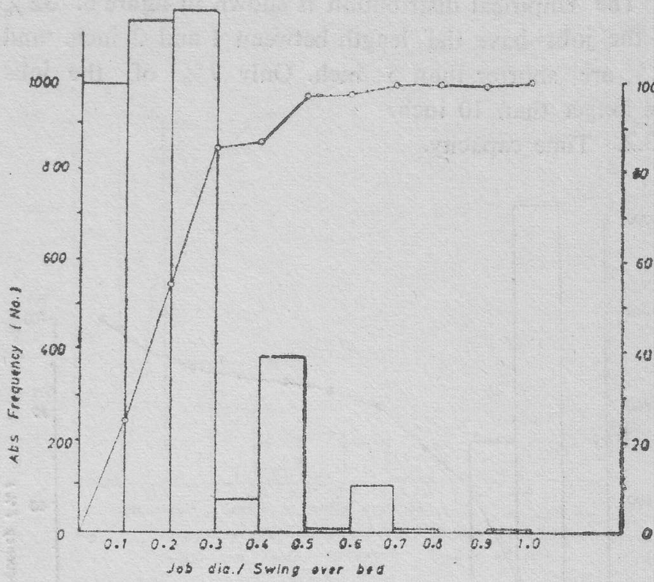

Fig. 4 : Frequency distribution of the ratio between job diameter and swing over bed

4.2.2. Time capacity

Fig. 5 represents the absolute and the cumulative frequency distribution. Jobs whose diameter is less then half the swing keep the lathes busy for over 85% of the time.

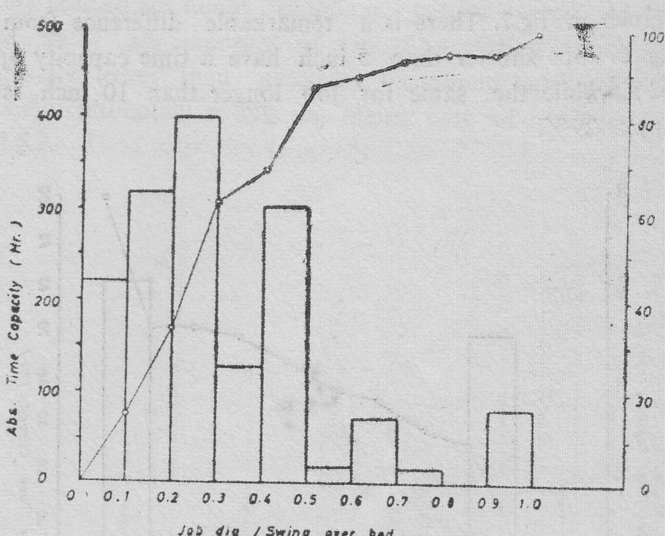

Fig. 5 : Frequency distribution (T.C.) of the ratio between job diameter and swing over bed of lathe

4.3. Frequency distribition of job length.

4.3.1. Absolute frequency distribution.

The empirical distribution is shown in figure 6. 32% of the jobs have the length between 1 and 2 inch. and 82% are shorter than 5 inch. Only 7% of the jobs are longer than 10 inch.

4.3.2. Time capacity.

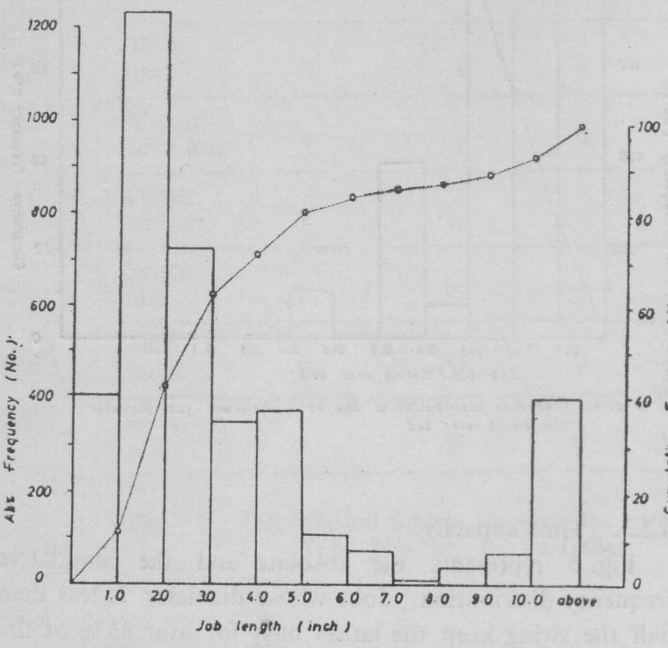

Fig. 6 Frequency of job length

Time capacity of the empirical distribution has been shown in fig.7. There is a remarkable difference from fig. 6. Jobs shorter than 5 inch have a time capacity oȷ 53%, while the same for job longer than 10 inch is appx. 29%.

Fig. 7: Frequency distribution (T.C.) of job.length (inch)

4.4. The ratio between job length and job diameter (l/d).

4.4.1. Absolute frequency distribution (fig.8).

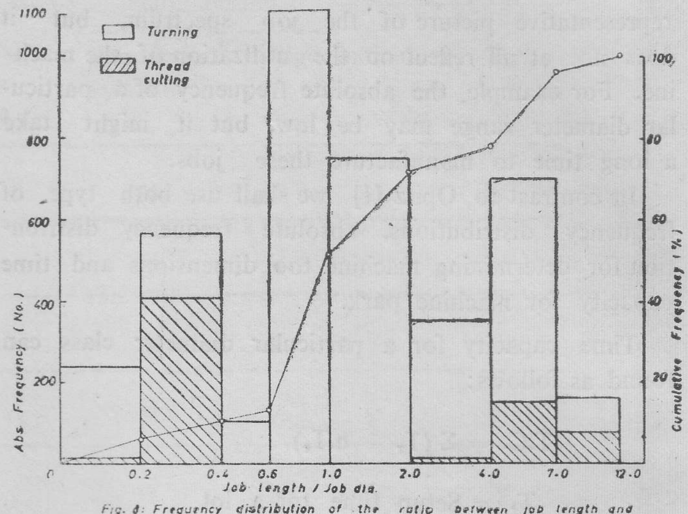

Fig. 8: Frequency distribution of the ratio between job length and job diameter

In the empirical distribution half the jobs have the job length equal to or less than the job diameter, while in appx. 73% of the cases the job length is less than double the job diameter.

Further more quite a few number of jobs require thread cutting.

4.4.2. Time capacity (Fig.9).

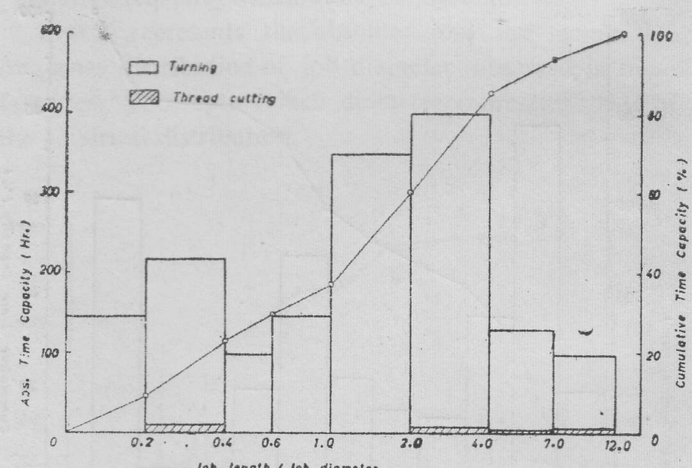

Fig. 9: Frequency distribution (T.C.) of the ratio between job length and job diameter

Table 1. shows some important features of this distribution.

l/d	time capacity
upto 1.0	37%
upto 2.0	60%
upto 4.0	83%

Table 1. Some important characters of time capacity distribution of l/d ratio.

This figure has shown that thread cutting is much less important.

4.5. The ratio between job length and center to center distance.

4.5.1. Absolute frequency distribution.

Fig. 10 shows that in the empirical distribution most of the jobs ane much smaller than the bed length of the lathe. Approxmalety 77% of the jobs are using only 10% of the maximum possible length, while for 95% of the jobs r is less than 0.3,

$$\text{where } r = \frac{\text{job length}}{\text{center to center distance}}$$

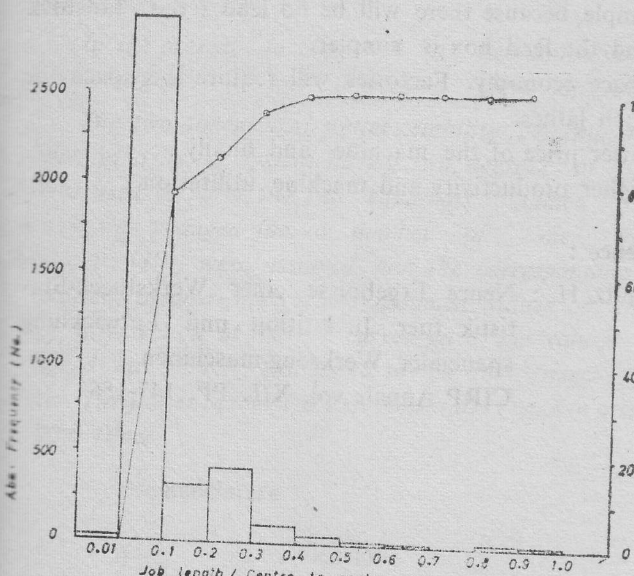

Fig. 10 : Frequency distribution of the ratio between job length and centre to centre distance of lathe

4.5.2. Time capacity (fig. 11)

Jobs having r value less than 0.1, occupy the lathes for approximately 43% of the total time, while the same with r value less than 0.3 occupy for 81% of the total time.

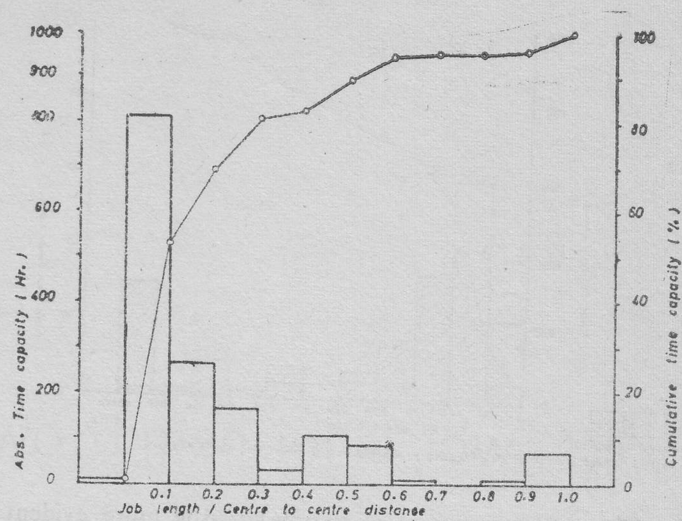

Fig. 11 : Frequency distribution (T. C.) of the ratio between job length and centre to centre distance of lathe

4.6. Frequency distribution of the spindle speed

4.6.1. Absolute frequency distribution of the spindle speed

Fig. 12 shows the actually used spindle speed and the economic cutting speed (the shaded columns). Apparenty both the management as well as the turners are less concerned about economic cutting speed. Many of them are ignorant of it. The cutting speed, in usually lower than necessary economic cutting speed which ultimately results in higher cost of production.

4.6.2. Time capacity (Fig. 13)

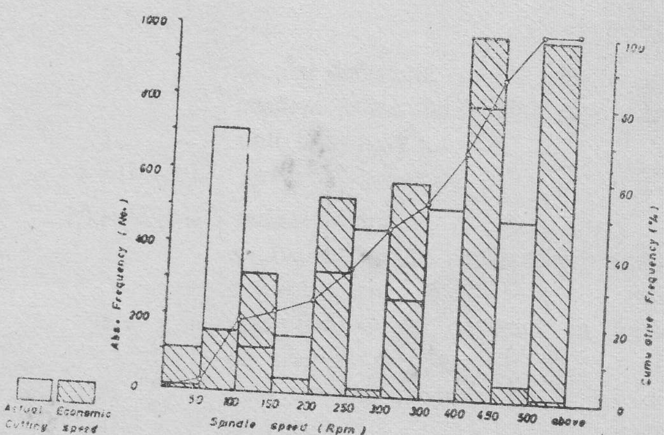

Fig. 12 Frequency distribution of spindle speed

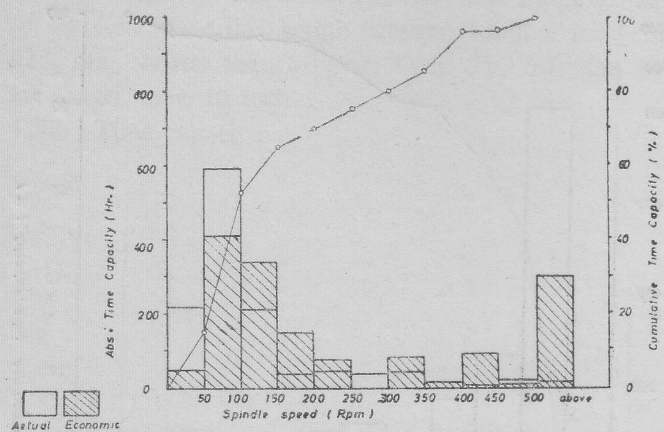

Fig. 13 Frequency distribution (T.C.) of spindle speed

The earlier comment of spindle speed is more evident from fig. 13. The lathes are engaged for more then 50% of the time with spendle speeds less than or equal to 100 rpm, while spindle speeds above 500 rpm are not practically used.

5.0 Conclusion.

On the basis of this research it can be ascertained, which type of lathe could serve the purpose of production in these factories. Table 2 shows the comprehensive data.

Characteristics upto M	Cumulative frequency (%)	Time capacity (%)
8″ dia × 8″ length	81.01	56.52
450 rpm.	88	96

Table : 2 : Comprehensive data of the job spectrum of three factories.

Thus a lathe having 8-10 inch swing and bed length upto 12-15 inch could turn 81% of the jobs. This lathe need not have any tailstock and lead screw. Thus feed box design will be simple. It is sufficient to design the gear box for the maximum spindle speed of 450 rpm.

Such a lathe will necessarily be cheaper than the smallest lathe (4 feet) that is now available in the market.

If further study shows that such small lathes have sufficient demand, the manufacture of this new model of lathes will have amongst others the following advantages :

1. less material will be required for the construction of a lathe. The new model can easily save as much as 50% of the material required for the smallest lathe available in the market. In our country where there in acute shortage of steel, this could go a long way to reduce material investment.
2. simple, because there will be no lead screw, tailstock and the feed box is simpler.
3. Space economy. Factories will require less space for such lathes.
4. lower price of the machine. and finally
5. higher productivity and machine utilitation.

Reference :

[1] Opitz, H. : Neure Ergebnisse einer Werkstueck-Statistik fuer Investition und Entwicklung spanender, Werkzeug-maschinen CIRP Annals vol. X/1, PP. 147-156.