- In the fi rst method, a derived series is obtained by taking every second, third, fourth or pth term of a given basic series. Such a derived series is designated by the symbol of the basic series followed by the number 2, 3, 4 or p and separated by '/' sign. If the series is limited, the designation also includes the limits inside the bracket. If the series is unlimited, at least one of the numbers of that series is mentioned inside the bracket. Let us consider the meaning of these designations.
- (i) Series R 10/3 (1, … ,1000) indicates a derived series comprising of every third term of the R10 series and having the lower limit as 1 and higher limit as 1000.
- (ii) Series R 20/4 (…, 8, …) indicates a derived series comprising of every fourth term of the R20 series, unlimited in both sides and having the number 8 inside the series.
- (iii) Series R 20/3 (200, …) indicates a derived series comprising of every third term of the R20 series and having the lower limit as 200 and without any higher limit.
- (iv) Series R 20/3 (…200) indicates a derived series comprising of every third term of the R20 series and having the higher limit as 200 and without any lower limit.
- In the second method, the derived series is obtained by increasing the numbers of a particular basic series. Let us consider an example of a derived series of numbers ranging from 1 to 1000 based on the R5 series. From Table 1.2, the are as follows:
- 1, 1.6, 2.5, 4, 6.3, 10 The next numbers are obtained by multiplying the above numbers by 10. They are as follows: 16, 25, 40, 63, 100
- The same procedure is repeated and the next numbers are obtained by multiplying the above numbers by 10. 160, 250, 400, 630, 1000
- Therefore, the complete derived series on the basis of R5 series is as follows: 1, 1.6, 2.5, 4, 6.3, 10, 16, 25, 40, 63, 100, 160, 250, 400, 630, 1000
- The advantage of derived series is that one can obtain geometric series for any range of numbers, that is, with any value of the fi rst and the last numbers. Also, one can have any intermediate numbers between these two limits.

Example 1.1 *Find out the numbers of the R5 basic series from 1 to 10.*

Solution

Step I Calculation of series factor

The series factor for the R5 series is given by

$$\sqrt[5]{10} = 1.5849$$

Step II Calculation of numbers

The series R5 is established by taking the first number and multiplying it by a series factor to get the second number. The second number is again multiplied by a series factor to get the third number. This procedure is continued until the complete series is built up. The numbers thus obtained are rounded.

First number = 1

Second number = 1 (1.5849) = 1.5849 = (1.6)

Third number $= (1.5849)(1.5849) = (1.5849)^2$

$= 2.51 = (2.5)$

Fourth number $= (1.5849)^2(1.5849) = (1.5849)^3$

$= 3.98 = (4)$

Fifth number $= (1.5849)^3(1.5849) = (1.5849)^4$

$= (6.3)$

Sixth number $= (1.5849)^4(1.5849) = (1.5849)^5$

$= (10)$

Example 1.2 *Find out the numbers of R20/4(100, ..., 1000) derived series.*

Solution

Step I Calculation of series factor

The series factor for the R20 series is given by

$$\sqrt[20]{10} = 1.122$$

Step II Calculation of ratio factor

Since every fourth term of the R20 series is selected, the ratio factor (ϕ) is given by,

$$\phi = (1.122)^4 = 1.5848$$

Step III Calculation of numbers

First number = 100

Second number = 100(1.5848) = 158.48 = (160)

Third number $= 100(1.5848)(1.5848) = 100(1.5848)^2$

$= 251.16 = (250)$

Fourth number $= 100(1.5848)^2(1.5848)$

$= 100(1.5848)^3 = 398.04 = (400)$

Fifth number $= 100(1.5848)^3(1.5848)$

$= 100(1.5848)^4 = 630.81 = (630)$

Sixth number $= 100(1.5848)^4(1.5848)$

$= 100(1.5848)^5 = 999.71 = (1000)$

In the above calculations, the rounded numbers are shown in brackets. The complete series is given by

100, 160, 250, 400, 630 and 1000

Example 1.3 *A manufacturer is interested in starting a business with five different models of tractors ranging from 7.5 to 75 kW capacities. Specify power capacities of the models. There is an expansion plan to further increase the number of models from five to nine to fulfill the requirement of farmers. Specify the power capacities of the additional models.*

Solution

Part I Starting Plan

Step I Calculation of ratio factor

Let us denote the ratio factor as (ϕ). The derived series is based on geometric progression. The power rating of five models will as follows,

$$7.5(\phi)^0, 7.5(\phi)^1, 7.5(\phi)^2, 7.5(\phi)^3 \text{ and } 7.5(\phi)^4$$

The maximum power rating is 75 kW. Therefore,

$$7.5(\phi)^4 = 75 \quad \text{or} \quad \phi = \left(\frac{75}{7.5}\right)^{1/4}$$

$$= (10)^{1/4} = \sqrt[4]{10} = 1.7783$$

Step II Power rating of models

Rating of first model = (7.5) kW

Rating of second model = 7.5(1.7783) = 13.34 = (13) kW

Rating of third model = $7.5(1.7783)^2$ = 23.72 = (24) kW

Rating of fourth model = $7.5(1.7783)^3$ = 42.18 = (42) kW

Rating of fifth model = $7.5(1.7783)^4$ = 75.0 = (75) kW

Part II Expansion Plan

Step III Calculation of ratio factor

When the number of models is increased to nine, the power rating of nine models will be as follows:

$$7.5(\phi)^0, 7.5(\phi)^1, 7.5(\phi)^2, 7.5(\phi)^3, 7.5(\phi)^4, \ldots, 7.5(\phi)^8$$

The maximum power rating is 75 kW. Therefore,

$$7.5(\phi)^8 = 75 \quad \text{or} \quad \phi = \left(\frac{75}{7.5}\right)^{1/8}$$

$$= (10)^{1/8} = 1.3335$$

Step IV Power rating of models

The power rating of the nine models will be as follows:

First model = $7.5\ (1.3335)^0$ = (7.5) kW

Second model = $7.5\ (1.3335)^1$ = 10.00 = (10) kW

Third model = $7.5\ (1.3335)^2$ = 13.34 = (13) kW

Fourth model = $7.5\ (1.3335)^3$ = 17.78 = (18) kW

Fifth model = $7.5\ (1.3335)^4$ = 23.72 = (24) kW

Sixth model = $7.5\ (1.3335)^5$ = 31.62 = (32) kW

Seventh model = $7.5\ (1.3335)^6$ = 42.17 = (42) kW

Eighth model = $7.5\ (1.3335)^7$ = 56.24 = (56) kW

Ninth model = $7.5\ (1.3335)^8$ = 74.99 = (75) kW

Part III Power capacities of additional models

It is observed that there are four additional models having power ratings as 10, 18, 32 and 56 kW.

Example 1.4 *It is required to standardize eleven shafts from 100 to 1000 mm diameter. Specify their diameters.*

Solution

Step I Calculation of ratio factor

The diameters of shafts will be as follows:

$100(\phi)^0, 100(\phi)^1, 100(\phi)^2, 100(\phi)^3, \ldots, 100(\phi)^{10}$

The maximum diameter is 1000 mm. Therefore,

$$100(\phi)^{10} = 1000 \quad \text{or} \quad \phi = \left(\frac{1000}{100}\right)^{1/10}$$

$$= (10)^{1/10} = \sqrt[10]{10}$$

Therefore the diameters belong to the R10 series.

Step II Calculation of shaft diameters

Since the minimum diameter is 100 mm, the values of the R10 series given in Table 1.2 are multiplied by 100. The diameter series is written as follows:

100, 125, 160, 200, 250, 315, 400, 500, 630, 800 and 1000 mm

ERGONOMIC CONSIDERATIONS IN DESIGN

Ergonomics is defi ned as the relationship between man and machine and the application of anatomical, physiological and psychological principles to solve the problems arising from man–machine relationship. The word 'ergonomics' is coined from two Greek words—'ergon', which means 'work' and 'nomos', which means 'natural laws'. Ergonomics means the natural laws of work. From design considerations, the topics of ergonomic studies are as follows:

(i) Anatomical factors in the design of a driver's seat

(ii) (ii) Layout of instrument dials and display panels for accurate perception by the operators

(iii) (iii) Design of hand levers and hand wheels

(iv)(iv) Energy expenditure in hand and foot operations

(v) (v) Lighting, noise and climatic conditions in machine environment Ergonomists have carried out experiments to determine the best dimensions of a driver's seat, the most convenient hand or foot pressure or dimensions of levers and hand wheels.

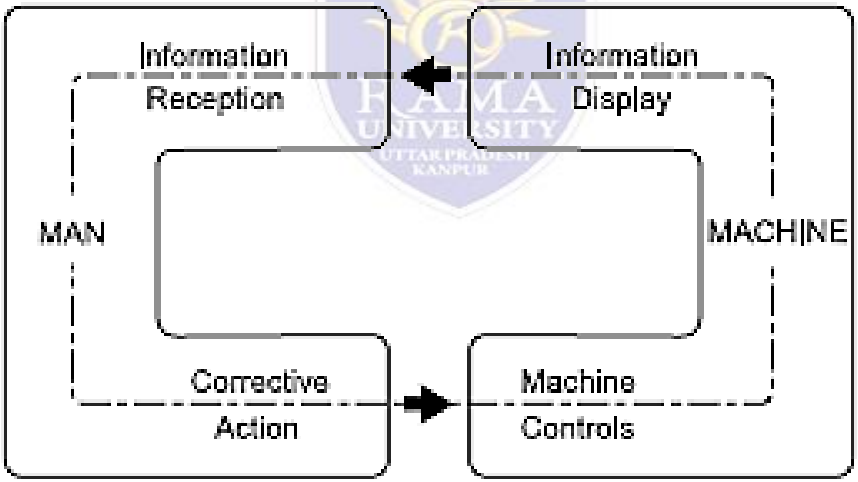

Fig. 1.6 *Man–Machine Closed-Loop System*