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**Rus-Eng 1**

S-SHAPED MODELS APPLICATION FOR RESEARCH OF TECHNICAL SYSTEMS DYNAMICS

The first mention of the S-shaped systems development can be attributed to the middle of the 19th century for forecasting the country's population in the form of logistic curves of such authors as Verhulst, Pierre Francois [1], as well as the Gompertz curve and the Pearl curve.

In 1975 G.S. Altshuller used S-shaped curves to predict the development of technical systems [2].

Studies conducted in various fields of knowledge have shown that models based on S-shaped curves quite well describe the dynamics of a wide variety of natural, technical, economic, and sociocultural processes. The monograph by J. Martino [3] provides various examples of processes that are well subordinate to the S-shaped development model:

- weight increase of the pumpkin as it grows in the garden;

- quantitative growth of the population of yeast bacteria.

Such curves are characterized by: an asymptotic tendency to 0 with decreasing time t, and a tendency to some upper limit L with time increasing; the presence of a period of accelerated growth - until tb moment; the presence of a period of growth retardation - after tb moment.

To describe these dependencies, in particular, the Pearl-Read and Gompertz equations presented in formula 1 are used.

These formulas are obtained as solutions of differential equations, describing the development of populations of living organisms. The justification for the legitimacy of using these formulas is based on some analogies between biological, on the one hand, and economic and technical processes, on the other hand [3,5].

One of the flaws of this approach is the lack of the beginning and end of the process. In real processes developing in a finite period of time, it is impossible to interpret the asymptotic desire for a quantity. This fact reduces the possibility of using the model, in particular, for predicting the processes under study. These considerations caused the need to develop another mathematical two-link S-shaped model shown in Figure 1 [4].

Denote the time interval of the process development [t0, tf], the corresponding values ​​of the studied indicator:

P (t0) = P0, P (tf) = Pf

A feature of this curve is: continuity; smooth growth (continuity of the first derivative); the presence of points of beginning and end of the limit; the whole curve is determined by three reference points: O, A, B, C, D, F.

The authors tested this model on well-known statistical material. Considered: the dynamics of petroleum production by the OPEC organization (Figure 2), the dynamics of production of cast iron (Figure 3), steel (Figure 4) and finished steel, (Figure 6). The experiment consisted in approximating the values ​​of statistical data and the calculated data of a two-link s-shaped model.

The accuracy of the approximation was estimated by the relative deviation at each point and the standard deviation. The standard deviation does not exceed 6% for OPEC petroleum production (Figure 3), 5% for cast iron production (Figure 4), 8.5% for steel production (Figure 5) and 5% for finished steel production (Figure 6), and the relative deviation at 8 points is more than 10% for OPEC oil production, at 21 points more than 10% for cast iron production, at 22 points more than 10% for steel production and there are no points at which more than 10% for finished steel production.

In conclusion, it should be noted that the studied model of the two-link s-shaped model is promising for further studies. This model can be used both in the metallurgical industry and in any other.