In order to improve the output of automatic assembly machines, one must not only improve their inherent reliability, but also minimise the downtime due to the lack of machined parts. The downtime essentially depends on both the mean output of the machines and transfer lines supplying the assembly machine with parts and the fluctuations in their production rate over a given time interval (hour or shift), as measured by their capability to run at a given speed. Methods are presented for analysing the effect of variations in piece part production on assembly output, and for determining what size of part stocks (buffers) are required to offset the fluctuations in piece part production.

Keywords: Automatic assembly; Buffer stocks; Downtime simulation; Weibull distribution

1. Introduction

In the machine shops of today, which manufacture large numbers of products, facilities include transfer lines, semi-automatic and automatic machines, and assembly lines for subassemblies and complete assemblies. In this environment, the probability that the production goal will not be achieved because assembly equipment is idle is higher than in the case of manual assembly. Therefore, the productivity of assembly automata and automated lines depends not only on their performance, but also on that of the complex integration of equipment that is required to carry out all the manufacturing steps towards the finished product.
Time studies of assembly lines and associated equipment have demonstrated that the output of an assembly line depends not only on the average output of the preceding equipment, but also on fluctuations in their productivity.

That is why the correct solution of two problems is a prerequisite for designing assembly processes of parts and machines and for selecting assembly-line layouts:

1. The productivity of assembly lines should be accurately determined relative to the reliability of each assembly operation and the inter-operation stocks (buffers) of partly assembled products [1, 2]. This problem is most difficult in the case of nonsynchronous lines where certain assembly operations are done manually and where assembly times are dependent on both operator skills and the precisional reliability of the parts being assembled.

2. It is necessary to take into account the effect of parts failing to arrive for assembly because of the unreliability of the machinery producing them and to determine the optimal buffer stocks of each part required between assembly operations. In doing so, it is important to have information not only on mean machine reliabilities, but also on the smoothness of their production rates (deviations in their productivities from the mean value) over any given time interval.

In the literature dealing with production-system reliability, it is noticeable that the problem of equipment production rate is not only unsolved, but has not even been formulated at all [3–5].

2. Methods and Results of Studying Production Rates of Equipment

Fig. 1 depicts the variations in the productivity and utilisation factor of a line producing shock-absorber cylinders, which are subsequently fed to an assembly line. It can be seen that the actual output of the line per shift \( Q(T_{sh}) \) differs significantly from its mean value \( \bar{Q}(T_{sh}) \) as determined over 25 shifts because of different totals of downtime for each shift.

Essential variations in shift productivity can lead to a failure to fulfil the production goals for the product as a whole or can mean that stocks of intermediate parts and assemblies are required between transfer lines, assembly machines and the line for general shock-absorber assembly. Increasing the stock of the parts used in the assembly enables fluctuations in shift output to be reduced but at the same time leads to higher amounts of work in progress and, consequently, to higher storage costs.

Determination and analysis of factors influencing the interrelational stability of metal-processing and assembly equipment should allow one to control production stability, both at the design stage and during equipment operation, and to establish optimal levels of part stocks required for smooth operation of lines and areas for sub and final assembly.

Table 1 summarises the data for four automatic assembly lines. It can be seen that the line utilisation time varies from 63.2% to 80.3% of the total time. The downtime due to the lack of parts or units is appreciable. The role