Chapter 5
Continuous Risk Stream

5.1 Line Design Without Stoppers

5.1.1 Introduction

Assembly systems in manufacturing often consist of multiple production stations connected by conveyors to transport and store materials [15]. There are the two major types of arrays of unit stations: line type and flexible type.

They differ in material flows of processed and overflow items. The line type [12] is usually known as the line-production system in which items are continuously processed in a series of stations and become finished products in the last station. We call it Assembly Line Systems (ALSs) based on a station-centered approach [7, 11].

The ALS has two cases with or without stoppers, which prevent the overflow of items. The former system is known as free-flow lines (e.g., [13]), in which usables wait in each station until their processing is over, and only processed items are outputted. The latter system is known as the case with conveyor pace [5]. In that case, the usables are continuously transported by power conveyors, and the overflows that have not been finished arise inevitably.

In designing the ALS, the assembly line balancing (ALB) problem [3, 15] occurs. The problem involves assigning the element tasks work to stations satisfying the precedence relation among the tasks and optimizing an objective function. In the cases with stochastic variations, such as the arrival/service times, the problem is called the stochastic ALB problem.

A usable, which is processed on the ALS, often requires more than the cycle time under the stochastic variations. The ALS design needs two determinations of not only cycle time but also buffer design for absorbing the variations. In the traditional ALS design, there is a (simple) two-step procedure (e.g., [1]), but it is not a simultaneous design procedure with feedback and costs.

This chapter applies a framework of a two-stage design method [9, 10], and proposes a two-stage design method, which unifies the combinatorial line-balancing problem and stochastic buffer-design problem [16]. This method is applied here to the ALS without stoppers in which the unit station is regarded as the Generalized Conveyor-Serviced Production Station (CSPS) [1, 8].

The design problem of the ALS without stoppers is then considered as a coordination problem between the unit stations (Generalized CSPSs). By simulation
optimization, the station-centered approach is first prepared. Next, the two-stage design method is developed. Finally, the design procedure is established.

5.1.2 Explanation of the Model

5.1.2.1 Two-Level Approach

For the assembly line, the Generalized Conveyor-Serviced Production Station (Generalized CSPS) is used as a unit station based on a station-centered approach. We regard the ALS without stoppers as a series array of Generalized CSPSs (Fig. 5.1.1). In Fig. 5.1.1, it is considered that the assembly line system has the two-level structure: the buffer-design problem of each station in the lower level and the coordination problem of buffers by the cycle time in the upper level.

It is assumed that the usables flow is according to a regular arrival with the inter-arrival time $d$. The service time in each station is supposed to follow the Erlang distribution with mean $\bar{x}_i$. Under these assumptions, each station individually decides the buffer (look-ahead time) $c_i$ in order to minimize the total expected cost, which is the sum of buffer cost and delay-and-overflow cost.

Processed items, which are outputs from the prestation or are serviced by the relief workers because of overflows, become inputs into the poststation. After being serviced in all the stations from the head station to the last station, they become finished products.

Then, the traditional line balancing procedure may be changed as shown in Fig. 5.1.2.

Fig. 5.1.1 Two-level structure of the assembly line system