KANBAN-TYPE GRAPHIC MODEL OF SERIAL-PARALLEL MATERIAL PROCESSING WITH STOCKS ON THE FLOW

Gheorghe BONCOI, Ionel NOVAC, Magdalena BARBU


Key words: mixed, integrated Kanban graphic model.

1. CURRENT STATE AND GENERAL ASPECTS

This work is a natural continuation of the work [1]. That is why the basic principles, notations and conclusions of the work [1] will be used in this work, too.

In this work, the following additional notations will be used: Stli – the current work station, joining several machines, working posts of the same kind, which perform simultaneously, in parallel, the same technological operation, being placed on a technologically indivisible production area, connected in series, upstream and downstream, with another PL, Stl, technologically adjacent, requiring a branching post (PRe), called loading post (Pl), on the input, upstream, and a joining post (Pre), also called unloading post (Pd), on the output, downstream.

In Fig. 1, the Kanban graphic model is presented, and in Fig. 2 – the complete serial-parallel (mixed) material processing cycle, with stocks on the flow.

2. THE NEED FOR A WORK STATION WITH POSTS IN PARALLEL

In a serial manufacturing system as in [1], in actual manufacturing environments, it is possible that Tci−1 ≠ TCi ∆ TCi+1, and (Tci−1) ∆ TCi+1 << TCi, so that Tci = kci−1Tci−1 and Tci = kci+1TCi+1, in which (kci−1) ∆ kci+1 > 1; this results in very big asynchronisms Δ Tci−1 = Tci−1 − Tci−1, Δ Tci+1 = Tci+1 − Tci+1, which do not provide the rhythmicity called for the production. In order to provide the rhythmicity called for the production in an imposed actual time fund, the technical solution allowed remains the use of a work station with identical posts in parallel, as in Fig. 1.

The partition of three identical working posts in parallel (PLi−1, PLi, PLi+1) is considered, where j is the current index of the working post in parallel, 1 ≤ j ≤ pi, i ∈ N, partition forming the current Stli, equivalent to PLi of [1], in a serial SFA; there is the assignment OTj → Stli, with Tci subject to the above conditions and restrictions. If PLi−1 and PLi+1 provide the rhythmicity called for the production, then, in order to be able to provide it, Stli should be composed of pi = max(Tci/Tci−1, Tci−1/Tci+1, ..., Tci/Tci+1), and pi ∈ N posts in parallel, which should function with staggered internal cycles, with fmax = p, called staggering factor, expressed by the number pi of identical posts in parallel from Stli.

Any PLj ⊂ Stli functions with Tci−1 = Tcj = Tci+1 = Tc, but staggered in time with the moments ti−1 < ti < ti+1, so that tj = Tci/pi and ti−1 → Tci−1, ti+1 → Tci+1, form the simply ordered sequence (ti−1, ti+1)) < (ti−1, ti+1) < (tlj+1, tj+1), which must fulfill the functional precedence condition (ti−1+1Tci−1 < (tj+1) < (tj+1+1)Tj+1) or (ti−1+1Tj+1) < (tj+1+1Tj+1) and (tj+1+1Tj+1), from which it follows that tj = Tci/pi, tli−1 < Tci+1, and tli−1 = Tci.

3. STRUCTURE OF STATION Stli

In the conditions and with the restrictions above, PLi of [1] turns into a Stli with the following structure, requiring:

• a loading post (Pl) on the input Stli upstream, with the function of material distribution (PRA) in ∀PLj ⊂ Stli;
• an unloading post (Pd) on the output Stli downstream, with the function of joining (Pre) the materials collected from ∀PLj ⊂ Stli;
• two storers: one STli coupled with Pi and the other STli coupled with Pd, both movable between two adjacent points, in Kanban relation;
• a proper and particular communications system, in Kanban relation;
• in such a structure, Stli becomes a parallel technological module in structuring a serial material flow, in Kanban relation, as in [1].
Fig. 1. Kanban serial-parallel graphic model with stocks on the flow.
Fig. 2. The complete serial-parallel (mixed) material processing cycle, with stocks on the flow.
4. IDENTIFICATION OF MATERIAL ACTIVITIES

In a St, parallelly aggregated of \( p_i \), PL\(_{j,p} \), the material activities are divided into two categories:

- activities outside the station: \( Lv/Tp_{(i-1)} \) and \( Lv/Tp_p \);
- activities inside the station: \( Al_i | Al_{(j-1)} | E_j | Ev_j \).

The corresponding informatic activities are also of two types:

- outside the station: \( SKC_{(i+1)} \), \( SKC_{(i+1)d} \), \( SKC_{(j-1)} \);
- inside the station: \( SKC_{(j-1)d} \), \( SKC_{(j-1)d} \)

5. PARTIAL AND GLOBAL CYCLES

The partial cycle is that corresponding to a single working post of the station and can be any PL\(_p \), \( 1 \leq j \leq p_i \), being identical for \( \forall j < p_i \) and it consists of the ordered sequence of the inside activities:

\[ SKC_{jd} | SKC_{jd} | Al_i | E_j | Ev_j. \]

The global cycle is that corresponding to the entire work station and therefore it should also include, beside the internal couplings, the external ones, with the input and output exo environments:

\[ SKC_{jd} | SKC_{jd} | Al_i | E_j | Ev_j. \]

Fig. 3. Inputs/outputs diagram for a PL\(_p \) of St\(_j \).

In Fig. 3, the inputs and outputs of a PL\(_p \) are presented, and in Fig. 4 – the inputs and outputs of a St\(_j \).

The following rules result from the figures below:

- A parallel working post PL\(_p \) of a serial work station St\(_j \) has an informatic request input – SKC\(_{jd} \) in Kanban relation and a material output – Ev\(_j \);
- A serial work station St\(_j \) has, as in [1], equivalent to a current PL\(_p \), two inputs and two outputs each, pairs-one informatic and the other material.

6. SEQUENTIAL ORDERING OF THE CYCLES

According to the previous statement, the partial cycle for a certain PL\(_j \) from a certain St\(_j \), in Kanban relation, will be:

\[ (t + 61)(t + 62)(t + 63)(t + 64)(t + 65). \]

The global cycle for a St\(_j \) in Kanban relation will be:

\[ (t + 3)(t + 4)(t + 7)(t + 14)(t + 5) \ldots (t + 61)(t + 62)(t + 63)(t + 64)(t + 65) \ldots (t + 11). \]

7. CONCLUSIONS

Such a manufacturing structure, in Kanban relation, has been applied in an actual production environment and validated by animated and experimental simulation.

REFERENCES


Authors:
Drd. eng. ME I. NOVAC
Drd. eng. EcE M. BARBU
Ph.D. ME Gh. BONCOI, professor, “Transylvania” University of Brașov, I.E.S.P. Department, E-mail: magda.n@unitbv.ro