AUTOMATED HANDLING OF FAULTS IN A MODULAR ASSEMBLY SYSTEM

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AUTOMATED HANDLING OF FAULTS IN A MODULAR ASSEMBLY SYSTEM

Technical task:
In a modular assembly system, the workpieces are conveyed from one assembly site to the next assembly site by an automated guided vehicle system. This allows different assembly sequences for different products to be easily mapped. A great advantage of such a decoupled assembly system is that in the event of malfunctions, for example at machines, an alternative route to alternative stations can be selected, provided that these alternatives are available for an affected order. In this way, the production flow is maintained and does not come to a standstill, as would be the case in interlinked flow production.

Now the question arises how a scheduling algorithm, which calculates regular global schedules to control the production system, reacts to such a disruption situation.

Initial situation:
In reality, for the period of the malfunction, a temporary short-sighted control by means of priority rules is often switched over, i.e. the priority rules decide what happens next with which production order. In this way, one moves away from the basic idea of global, holistic problem solving and loses solution quality. In the event of a fault, manual intervention in the control system is sometimes necessary, which violates the idea of automated control.

Question How do I deal with such malfunctions as simply/simply and automatically as possible, but retain a global view of the system in order to continue to optimize throughput in modular assembly?

Solution:
A station in the modular assembly system is constructed as shown in Figure 1. An FTF delivers a production order at the infeed, which has a certain capacity for workpiece carriers. Then the station is passed through from left to right according to the FIFO principle. After processing, intermediate storage takes place on the exit buffer, also with a certain capacity. From there the workpiece carrier/order is picked up again by an FTF and brought to the next station.

Figure 1: Structure of a station.

If now a malfunction occurs in one of the modular stations, as shown in Figure 2, all workpiece carriers/orders to the left of the black line (including the machining station) are blocked, including the one on the FTF, if the infeed buffer is full. As long as the station is in disorder, it is not possible to continue with these jobs. However, the orders already lying on the outfeed buffer can be transported and processed further. All jobs not directly affected by the faulty station can also be processed further. The aim is now to re-route the following jobs as optimally as possible and thus to bypass the disturbed station for all production jobs not directly affected by the disturbed station that have alternative routes.

Figure 2: Fault in the station.

Figure 3 shows an exemplary production job in a modular system, represented as a directed tree. Each of the four paths is a valid solution for processing the job. Grey are the assembly operations, red are the stations where they can be performed.
If a station is now in trouble, for example "Station B", shown in Figure 4, the controller should try to bypass this station for all jobs that have a possibility to bypass the station. In the example shown, this means to select paths 3 or 4, not paths 1 or 2, because paths 3 and 4 can do without the disturbed station B.

Figure 3: Exemplary production order with four different assembly paths that can be run through in the modular system.

Figure 4: Bypassing the disturbed station for a job, deleting assembly paths.

Core of the idea:
In case of a malfunction, a new schedule calculation is now triggered which takes this malfunction into account. The Scheduling Run considers the following three points to find a holistic, global, automated and simple control solution for this situation:

- Orders that are directly affected by the disturbed station, i.e. that are located on the FTF in front of the station, in the infeed of the station or on the processing station (red in figure 2): These orders are not planned into the future for the period of the disturbance. Only the next pending or current processing at the disturbed station is considered and entered in the schedule to be calculated, so that the calculated schedule remains correct and a valid planning is to be carried out for jobs that are not an alternative station to the disturbed station. In addition, by not planning the blocked jobs into the future, it is prevented that other stations are unnecessarily occupied with the currently not feasible assembly scopes of the blocked jobs and thus other feasible jobs are blocked.

- Jobs that do not have alternative paths (i.e. different from Figure 4): Here, all paths are considered and placed behind the jobs already blocked directly by the station in the schedule (For the operations that MUST be performed at the disturbed station). Preference is given to those paths that arrive at the disturbed station as late as possible, in the hope that the disturbance has already been eliminated by then.

- Orders that have alternative paths available: Here only the alternative paths (paths 3 and 4 in figure 4) are considered for scheduling.

With these input parameters, the scheduler tries to calculate a schedule that is as optimal as possible, which as a whole tries to keep the production flow running as well as possible. If two or more disturbances take place in parallel, the scheduler also tries to keep the key points 1 to 3. Once a malfunction is over, a new scheduling run is also initiated in order to be able to carry out a complete, optimal planning again.

Advantages:

- Holistic optimization is maintained compared to manual intervention or short-sighted priority rules.
- Production flow can be maintained by bypassing disturbances as well as possible.
- The handling of disturbances is automated.