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# TOOL ALLOTMENT MODEL IN THE PRODUCTION SYSTEM

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**Abstract.** Any factory, whatsoever the product it processes and whatsoever the type of material processing, is vulnerable to internal perturbations, among whom the variation of the tool flux is of major importance. Preventing vulnerability is achieved through management in real time, which, for eliminating the penury and the surplus, has to ensure the minimal safety stock, regulated through managerial decision. The main issue of tool management consists in the fact that "at request, any tool, of any type and dimension, must be available within the right time, at the right place" so as to cast off the tool penury in the system.

**Keywords:** tool flow, management, monitoring

## 1. Introduction

The tool management strategy includes knowing the overall events occurring in the tool change process, their control and ordering, their evidence, as well as the monitoring and correcting decisions, their subsequent evolution into a strictly ordered and controlled succession [1]. The entire strategy is exclusively applied in the endo-environment. Its effects may be measured in the exo-environment only as internal perturbations with negative influence upon the output (finite tool).
One of the important issues in the tool management strategy consists in ordering the selection of the tool type from the multitude of tools within a store [2].

As compared to the semi-product flux, in the tool flux we cannot talk about a serving discipline, as the tool does not undergo a choice process; a tool, once having entered the flux, is simply used non-preferentially until total tear and wear, when it is replaced by another usable one.

## 2. Tool managing strategy

The principal issue for the tool managing strategy in the production system consists in the fact that "at request, any tool, of any type and dimension, must exist in the right time, at the right place" in order to eliminate the tool penury from the system. This is only possible through monitoring in real time and through strongly reactive operative-tactical management. The quantitative levels and the regulatory rhythms cannot be provisioned and therefore planned, as they depend on unpredictable random factors. The operative management of the tool management is effectively carried through monitoring their consumption in real time.

Tool monitoring consists in pursuing over the system and in and supervising their consumption almost on every machine throughout system, their spatial circulation on every trajectory of the itinerary transport plan and signaling the penury apparition danger for every tool in the system. Monitoring implies periodically elaborating monitoring reports and sending them over to the tool provisioning department and to the production planning department [3].

To avoid the penury of any tool in the local piling up stock, there has to be maintained a minimum quantitative level. To this purpose, any reduction in the quantitative level for any tool, brought along by any perturbation in the flux, must be corrected through an up-date re-provisioning of the quantitative level for the considered tool. The up-date is only done at request and effects in correcting the quantitative level only for the local piling up stock [4]. The up-dating consists in correcting the two monitored parameters, which are: the type s of the current tool ($1 \leq s \leq s_t$) and the level $N_s$ of the current tool $Sc_s$ ($N_s = 1+N_{STL\ Scs}$, where $N_{STL\ Scs}$ is the minimum necessary quantitative level in units, which must be found in the local tool piling up stock). Any up-date provisioning in the local piling up stock compulsorily stirs the tool circulation from the central piling up stock to the zonal piling up stock. Any reconditioned tool will bed re-allotted in the zonal piling up stock. To come up with a conclusion, any flawed tool imposes its replacement from the local piling up stock and it's up-dating with a new tool of the same type. The flawed tool follows a predetermined reconditioning or elimination procedure.

## 3. Rules in tool management

- ✓ Any component part, equipotent in the processing sub-system (SbPre), tool consuming, must have equal access to the tool resource (tool flux-$F_l$Sc);
- ✓ Any component part of the logistic sub-system of the tools ($SbLSc_s$) accesses $F_l$Sc observing its hierarchical priority and usually the FIFO ordering;
- ✓ A component part of SbPre, which currently holds a single tool of a certain type, becomes a priority in serving;
- ✓ If several requests for tools are currently issued simultaneously by several components of SbPre, the priorities in serving are set in the strict order of the technological-operation succession in the ordered file of the technological-process deployment;
- ✓ A broken, worn or flawed tool becomes of priority for its elimination from the local piling-up stock ($STL_i$, $1 \le i \le q_{tSM}$);
- ✓ A priority in serving consists in the strictly orderly succession: elimination of the flawed tool from the $STL_i$ followed by $STL_i$ feeding with a similar but functional tool from the zonal piling up stock ($STZ_\alpha$);
- ✓ The tools with great flawing susceptibility are stored and delivered / served in a group of 3-6 units of the same type, manoeuvrable in the box;
- ✓ Among the components SbLSc, the priorities are ordered this way: Local piling up stock ($STL_i$)└Zonal piling up stock ($STZ_\alpha$) └ Pre-regulating checkpoint (PPrereg) └ Pre-setting checkpoint (PSet) └ Central piling-up stock (STC) └ Tool sharpening checkpoint (PAsc) └ Waste checkpoint (PDeş);
- ✓ Any ScR passes through PDeş; any ScD passes through PPrereg and any ScU passes through PAsc; any ScB passes from a $STZ_\alpha$ in a $STL_i$ and any NEW Sc passes from STC through PPrereg in a $STZ_\alpha$.

The tool surplus in any hierarchical level is avoided. To this purpose, the tool flux ($F_l$Sc) functions as an integrated Kanban process. The standard minimum tool stock, which eliminates the apparition of the tool penury at whatsoever level, is thereby accepted.

## 4. Tool allotment model

Through allotment, programming one or several material fluxes for processing in the manufacturing system is understood. The allotment is only done upon the resources and consequently upon the tool flux.

The tool-flux elaboration model must be underlain by the equilibrium among request (C) – offer (O) – resource (R), wherein the request must have the same nature as the offer, and this is in accordance with the available resources. Any offer is limited by the maximum available level of the resources.

**Hypotheses:**

- The manufacturing is produced with ensured availability on the market (on the basis of firm orders from the customers – CzFCl) from the commodity market of Pf (PiDfPf);
- The level of the firm orders (NCzF) is current, variable and unpredictable within the range $\tau_f$=1 week, 1 month, 3 months, 6 months, 1 year and constant, known or predictable as time sampling k=1 hour, 4 hours, 8 hours, 16 hours or 24 hours, 1 day, 2 days, maximum 3 days;
- The resources (Sc) depend on orders (NCzF) and consequently vary once with the former within the specified ranges, consequently $NSc_s$ (NCzF);
- The tools are the resources existing in STC at a maximum admitted level (Nmax nec t), set through managerial decision (DMg), existing in $STZ_\alpha$ and in the $q_{tSM}$ $STL_i$ at an available level ($NdispSc_s$) from the previous range (k-1); ($NdispSc_s$), which is variable once with the current consumption, so the inputs in $STL_i$ and $STZ_\alpha$ are subject to the condition of stock-breakage avoidance; the STC provisioning with $Sc_s$ must avoid the stock breakage in STC;
- The tools are known as type, material and durability;
- The tools function under normal operating conditions for which their working life is known;
- In the real functioning of the production environment, functional blockages appear, being evaluated and standardized according to the internal and external disturbing factors make the planned production – desired ($P_{PL}=P_d$) to differ from the real one – achieved ($P_{Rz}=P_r$) and consequently NSc in SFa is variable, determined by the endogenous and exogenous perturbations.

As follows, the following notations will be explained: $Sc_s$ – current tool of the type s, $1 \le s \le s_t$, $s_t$ – total number of tool types necessary for material processing in SP global; $STL_iSc_s$ – local tool stock existing in the local stores $STL_i \rightarrow m_i$, $1 \le i \le q_{tSM}$; $CaSTL_i$ – storing capacity of the local store i; $STZ_jSc_s$ – zonal tool stock existing in the zonal stores $STZ_j$, $1 \le j \le \beta$, and $STZ_\alpha \rightarrow SbPre_\alpha$, $\alpha \subset \beta$; $\beta$ – number of zonal piling up stocks from SFa, $\alpha$ – current flexible cell $\alpha$ fed from $STZ_\alpha$, $\alpha \neq \beta$, (j,α,β)∈ N, $STCSc_s$ – central tool stock existing in the central store STC; NScPCt – number of tools existing in the $q_{tSM}$ control checkpoint; NScAtAsc – number of tools existing in the sharpening workshop; NScPSet – number of tools existing in the setting checkpoint; NScPPrereg – number of tools existing in the pre-regulating checkpoint; N – level; indices: d – desired, PL – planned, nec – necessary, cer – required, r – real, ex – existing, t – total, $z_j$ – zonal partial in $STZ_j$, $l_i$ – local, partial in $STL_i$, $z_t$ – zonal total in all β $STZ_j$, $l_t$ – local total in all $q_{tSM}$ $STL_i$, ε – error („-“ lack, deficit as against the necessary, „+” surplus as against the necessary).

With the notations above, the mathematical model of the tool stock (existing) will be:

**Equations of structure and level:**

$$STL_iSc_s = \{Sc_{si}, 1 \le s \le s_{li}\}$$
$$N_lSTL_i \le CaSTL_i$$
$$N_tSTL = \sum_{i=1}^{q_{tSM}} N_lSTL_i$$
$$STPC_t = \{Sc_{si}, 1 \le s \le s_{li} = s_{Ct}, 1 \le i \le q_{tSM}\}$$
$$NScPCt = \max \sum_{i=1}^{q_{tSM}} i$$
$$STZ_jSc_s = \{Sc_{sj}, 1 \le s \le s_{zj}, 1 \le j \le (\beta, \alpha)\}$$
$$N_zSTZ_j \le CaSTZ_j$$
$$N_tSTZ = \sum_{j=1}^{\beta} N_zSTZ_j = \sum_{\alpha=1}^{\beta_\alpha} N_zSTZ_\alpha$$
$$STCSc = \{Sc_s, 1 \le s \le s_{tC} \ge Sc_{nec}(\tau_f)\}$$
$$N_cSTC \le CaSTC$$
$$N_tSTC \ge N_{nec}Sc_s(\tau_f) \le N_{PL}Sc_s(\tau_f) \qquad (1)$$
$$STDeş = \{Sc_s, 1 \le s \le s_{tR} \to Sc_sR\}$$
$$N_tDeş = \sum_s Sc_sR$$
$$STAscSc = \{Sc_s, 1 \le s \le s_{tU} \le Sc_sU\}$$
$$N_tAsc = \sum_s Sc_sU$$
$$STSetSc = \{Sc_s, 1 \le s \le s_{tNOI} \to Sc_sNOIcer\}$$
$$STPreregSc = \{Sc_s, 1 \le s \le s \le Sc_sNOIcer, Sc_sD, Sc_sAsc\}$$
$$N_tPrereg = \sum_s Sc_s(NOIcer, D, Asc)$$
$$ST_tSFa = \{Sc_s, 1 \le s \le (s_{li}, s_{Ct}, s_{zj}, s_{tC}, s_{tU}, s_{tNOI}, s_{tD}, s_{tPrereg})$$

$$ST_tSFa = \{Sc_s, 1 \le s \le (s_{li}, s_{Ct}, s_{zj}, s_{tC}, s_{tU}, s_{tNOI}, s_{tD}, s_{tPrereg})$$
$$N_{tex}SFa = N_tScR = N_tDeş$$
$$N_t\,necSFa = N_{t\,ex}SFa + N_tScR \qquad (1)$$
$$N_tScB(k+1) + N_tScR(k+1) = N_{t\,nec}SFa(k) = N_{t\,disp}SFa(k+1)$$

**Equations of errors (corrections):**

$$\varepsilon_{ScBSTL_i}(k+1) = N_lSTL_i(k) - \varepsilon_{ScUSTL_i}(k) - \varepsilon_{ScDSTL_i}(k) - \varepsilon_{ScRSTL_i}(k) = N_{Al}STL_i$$
$$\varepsilon_{ScBSTZ_j}(k+1) = N_zSTZ_j(k) - \varepsilon_{ScUSTZ_j}(k) - \varepsilon_{ScDSTZj}(k) - \varepsilon_{ScRSTZ_j}(k) = N_{Al}STZ_j$$
$$\varepsilon_{ScBSTC}(k+2) = \sum_{i=1}^{q_{tSM}} \varepsilon_{ScBSTL_i}(k+1) + = \sum_{i=1}^{\beta} \varepsilon_{ScBSTZ_j}(k+1) + \varepsilon_{ScNOISet}(k+1) + \varepsilon_{ScNOI,D,Asc,Prereg}(k+1) = N_{nec}ScBSTC(k+1) - N_{ex}ScBSTC(k) = N_{Ap}STC \qquad (2)$$
$$N_{Ap}STC(k+1) = \sum_{i=1}^{q_{tSM}} N_{Al}STL_i(k) + \sum_{j=1}^{\beta} N_{Al}STZ_j(k) + \sum_{PSet,PPrereg} NSc_s(NOISet, D, Asc, Prereg)(k)$$
$$N_{PL}ScSFa(k+3) = \varepsilon_tSc_sSTC(k+2)$$
$$\underset{(a=L,Z,C,SFa)}{\varepsilon_{tex}Sc_sSTa} = N_{disp}Sc_sSTa - N_{ScR}Sc_sSTa$$

If k is the current stage (the current moment) in $F_lSc$ feeding and the necessary of tools is achieved during the stage (k+3), then the stages k-1|k|k+1|k+2|k+3 form a strictly orderly range in the tool-provisioning process and the partition <k-1,k,k+1,k+2,k+3> constitutes the outrunning duration of the tool provisioning, wherein activities prior to the tool provisioning take place.

In a production system (SP) of the type section or factory, several technological lines in flux exist (LThFl); likewise sectors of technological lines ($SL_{Th}$), manufacturing cells (CFF), manufacturing modules (MFFa) and machines ($m_i$), technological devices ($UT_i$), individual technological equipment ($IT_i$); each of the enumerated ones being functionally independent entities; therefore the decomposition SP (SFa) in a first hierarchical level in relation of subordination is expressed SFa(SP)={LThFl, $SL_{Th}$, CFF, MFFa, $m_i$, $UT_i$, $IT_i$, $STZ_\alpha Sc_s$, $1 \leq \alpha \leq n_{STSFa}$}, wherein $STZ_\alpha Sc_s$ is the current zonal piling up stock; α. $STZ_\alpha Sc_s$ may exist as deposits, sectorial, zonal shops, which serve a LThF, a $SL_{Th}$, a CFF, MFFa. The number $n_{STSFa} \subset SFa$ depends on the tool-management organization and the capacity of every $STZ_\alpha Sc_s$ is sized according to the minimum condition min $t_{aşt}$ in manipulating tools and to the removal of the tool-penury phenomenon in SbPre.

Any $STZ_\alpha Sc_s$ is fed with ScNOI from STC, with Sc (Prereg, D, Reasc) from PPrereg. ScB, after the control in $PC_{ti}$, through PSel, are also re-circulated towards $STZ_\alpha Sc_s$. Consequently, the inputs/outputs of a $STZ_\alpha Sc_s$ are presented in fig. 1.

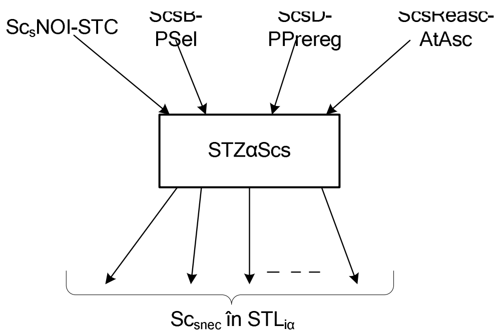


Figure 1. Inputs/outputs of a $STZ_\alpha$.

Any $STL_i$ stores the entire $SSc_s$, $1 \leq s \leq s_l$, necessary for executing the same type of operation $OT_{ik}$, i=ct, $1 \leq k \leq r$, for executing the diversity of processes {$Pr(R_k)$, $1 \leq k \leq r$} in a $\tau_f$ pre-defined through DMg. Any $STL_i$ is fed with good tools $Sc_sB$ from $STZ_\alpha Sc_s$ and, in its turn, it feeds its own machine.

Every machine or group of machines of the same type are served by a control checkpoint of the tools or of the processing (PCt) which, in an on-line/off-line regime, controls tool by tool the overall used or statistical ones and labels them in: good tools ($Sc_sB$), reusable, which are re-circulated in $STSc_sZ_\alpha$, or in the same $STL_i$; broken tools ($Sc_sR$), waste eliminated through PDeş; deregulated tools ($Sc_sD$) which are sent in PPrereg for a new adjustment and return in $STL_i$ as good tools; worn tools ($Sc_sU$) which are sent in AtAsc for re-sharpening and return in $STL_i$ from PPrereg as good tools.

Consequently, the scheme input/output of a $STL_i$ will be the one in fig. 2.

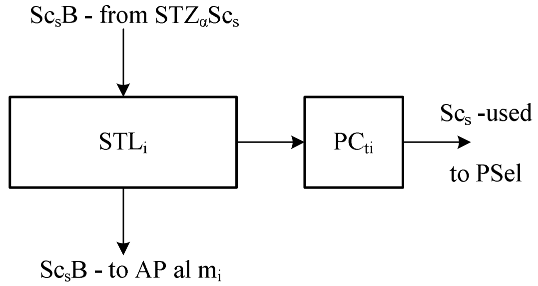


Figure 2. Input/output of a $STL_i$

## 4. Conclusions

From the above information and facts, it ensues that $FlSc_s$ is atypical, presenting the following particularities: the content of ($Sc_s$) does not change into a finite product, but it participates in synergy to the value Pf – of the processed piece; its only outlet manifests as waste, either as broken tool or as totally worn tool; the content, the tools are re-circulated in SFa, through AtAsc, several times, until the total consumption of every tool. These particularities must be considered in elaborating the allotment model and in monitoring the tools in the local stores, as they have powerful dynamics.

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