The Role of Time Factors in the Maintenance Logistics

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Abstract: - The shaping of the process of the maintenance logistics and the applied logistical strategies are basically determine the transit time of the maintenance activity by which the satisfying filling is substantially influenced of the given products customers. It was investigated whether which time parameters are determinable for the transit time.

Key-Words: - Time factors, transit time, maintenance process, object function

1 Basic Formulas
The basic condition of the start of the maintenance activity is the existence of the followings at the object under the activity:
- the necessary type of materials in suitable quality and quality,
- the necessary type of constituents in suitable quantity and quality,
- the necessary type of facilities in suitable quantity and quality,
- the necessary services to the maintenance and the staff.
The assurance of the above conditions is the task of the maintenance logistics. In case of the time parameters of the maintenance logistics two main factors are considered as can be seen in (1).

\[ t_a = t_M + t_H \]  \hspace{1cm} (1)

where \( t_M \) denotes the transit time of the order process of the necessities, and \( t_H \) stands for the time of demand of delivery, that is the total time of the logistical activities connected to the maintenance object. The ordering process of the necessities (materials, constituents, facilities, service, staff) can be seen in Figure 1. The transit time of the process of the order of the necessities

- for the materials of maintenance

\[ t_{MA_{i,j}} = \sum_{k_i=1}^{n_i} \Delta t_{i,j,k_i} \]  \hspace{1cm} (2)

where

\( i_a \) - is the identifier of the transporter,
\( j_a \) - is the identifier of the material which should be purchased,
\( k_a \) - is the identifier of the time increment of the process of ordering,
\( n_a \) - the maximum number of the time increment has been considered, which means the number of activity elements of the process of the ordering.

- for the constituents of the maintenance process

\[ t_{MC_{i,j}} = \sum_{k_r=1}^{n_r} \Delta t_{i,j,k_r} \]  \hspace{1cm} (3)

where

\( i_r \) - is the identifier of the transporter,
\( j_r \) - is the identifier of the constituent to be purchased,
\( k_r \) - is the identifier of the time increment at the ordering process,
\( n_r \) - the maximum number of the time increment has been considered, which means the number of activity elements of the process of the ordering.

- for the maintenance facilities

\[ t_{ME_{i,j}} = \sum_{k_e=1}^{n_e} \Delta t_{i,j,k_e} \]  \hspace{1cm} (4)

where

\( i_e \) - is the identifier of the transporter,
\( j_e \) - is the identifier of the constituent to be purchased,
\( k_e \) - is the identifier of the time increment of the ordering,
\( n_e \) - the maximum number of the time increment has been considered which means the number of activity elements of the process of the ordering.
- for the maintenance service

\[ t_{MS_{ijs}} = \sum_{k_s=1}^{n_s} \Delta t_{ijs,k_s} \]  

(5)

where

- \( i_s \) - is the identifier of the given service,
- \( f_s \) - is the identifier of the service to be purchased,
- \( k_s \) - is the identifier of the time increment of the ordering process,
- \( n_s \) - is the maximum number of the time increment has been considered which means the number of activity elements of the process of the ordering.

2 Determination of the transit time

By using (2), (3), (4) and (5) the transit time can be given for the materials, constituents, facilities and services which are necessary for the ordering of maintenance. It is expedient to write the followings:

\[ t_{MA_{ijs}} = \sum_{k_s=1}^{n_s} \Delta t_{ijs,k_s} = \min \]  

(6)

\[ t_{M_{i,j}f} = \sum_{k_r=1}^{n_r} \Delta t_{i,j,k_r} = \min \]  

(7)

\[ t_{ME_{ijs}} = \sum_{k_s=1}^{n_s} \Delta t_{ijs,k_s} = \min \]  

(8)

\[ t_{MS_{ijs}} = \sum_{k_s=1}^{n_s} \Delta t_{ijs,k_s} = \min \]  

(9)

In the followings the time factors to be connected with the demand of delivery of the necessities will be investigated. The time factors are belonging to the place where the necessity should be satisfied and to the object being under the maintenance. These factors can be:
- times for logistical activities,
- waiting times for the necessary facilities and equipments.

Logistical type of activities in field of maintenance logistics can be the next:
- different kind of storage activities, activities in connection with stores (transmission in and out), activities in connection with demolition or making of unit packages,
- commission,
- transportation,
- packing,
- classification
- removable constituent
- constituent for recycling
- pieces for putting as waste
The time necessity for the demand of delivery of maintenance will be given in Figure 2. taking the logistical type activities into regard.

The given constituent has to be removed from the original place and then after reparation should be put back. If the transportation is proceeded from the transportation in storage, (new or renovated constituent) then the time for demand of delivery is:

in case of parallel activity

\[ t_{HR1} = \max_{i_r} \{ t_{HR1,i_r} \} \]  \hspace{1cm} (10a)

in case of serial activity

\[ t_{HR1,i_r} = t_{\kappa_{i_r}} + t_{E_{i_r}} + t_{R_{i_r}} + t_{S_{i_r}} \]  \hspace{1cm} (10b)

where

- \( t_{HR1} \) – time of demand of delivery for given maintenance task in case of demand of delivery from store,
- \( t_{HR1,i_r} \) – time of demand of delivery of a transported constituent for the transporter \( i_r \) in case of given maintenance activity,
- \( t_{\kappa_{i_r}} \) – the storage time necessity in case of supply between the transporter \( i_r \) and the maintenance object,
- \( t_{E_{i_r}} \) – the time necessity for forming and demolition of unit package in case of supply between the transporter \( i_r \) and the object under maintenance,
- \( t_{R_{i_r}} \) – the time necessity for commission in case of supply between the transporter \( i_r \) and the object under maintenance,
- \( t_{S_{i_r}} \) – the time necessity in case of supply between the transporter \( i_r \) and the object under maintenance.

\[ t_{\kappa_{i_r}} = \sum_{j_r=1}^{n_r,i_r} \sum_{k_{i_r,j_r}=1}^{n_{i_r,j_r}} t_{\kappa_{i_r,j_r}} \]  \hspace{1cm} (12)

where

- \( t_{\kappa_{i_r,j_r}} \) – the storage time in the sore \( \kappa_{i_r} \) for the constituent \( j_r \) and transporter \( i_r \) during the supplying process,
\( n_{r_i} \) - the number of stores for the constituent \( J_r \) and transporter \( I_i \) during the process of supply,

\( n_{i_j} \) - the number of transported constituents in case of transporter \( I_i \),

\( n_i \) - number of the transporters being involved.

\[
t_{E_r} = \sum_{j=1}^{n_i} \sum_{s=1}^{n_{r_j}} t_{E_{r_i,j,s}}
\]

(13)

where

\( t_{E_{r_i,j,s}} \) - the time for the construction and demolition of the unit packages \( \kappa_s \) at the constituent \( \kappa_i \) and transporter \( I_i \) during the process of supply,

\( n_{r_j} \) - the number of construction and demolition of unit packages in case of transporter \( I_i \) and constituent \( J_r \) during the process supply.

\[
t_{K_i} = \sum_{j=1}^{n_i} \sum_{s=1}^{n_{r_j}} t_{K_{r_i,j,s}}
\]

(14)

where

\( t_{K_{r_i,j,s}} \) - the time for commission \( \kappa_s \) in case of the transporter \( I_i \) and constituent \( J_r \) during the process supply,

\( n_{s_k} \) - the number of commission in case of the transporter \( I_i \) and constituent \( J_r \).

\[
t_{R_s} = \sum_{j=1}^{n_i} \sum_{s=1}^{n_{r_j}} t_{R_{s_i,j,s}}
\]

(15)

where

\( t_{R_{s_i,j,s}} \) - the time for storage \( \kappa_s \) in case of constituent \( J_r \) and transporter \( I_i \) in case of the process of supply,

\( n_{s_k} \) - the number of storage in case of the constituent \( J_r \) and transporter \( I_i \).

\[
t_{S_{s_k}} = \sum_{j=1}^{n_i} \sum_{s=1}^{n_{r_j}} t_{S_{s_i,j,s}}
\]

(16)

where

\( t_{S_{s_i,j,s}} \) - the transportation time \( \kappa_s \) in case of the constituent \( J_r \) and transporter \( I_i \) in the process of supply,

\( n_{s_k} \) - the number of transportations in case of constituent \( J_r \) and transporter \( I_i \).

Summarizing the content of (10), (11), (12), (13), (14), (15), (16):

\[
t_{\text{opt}} = \max \left[ \sum_{r=1}^{n_i} \sum_{s=1}^{n_{r_j}} t_{t_{E_{r_i,j,s}}} + \sum_{r=1}^{n_i} \sum_{s=1}^{n_{r_j}} t_{K_{r_i,j,s}} + \sum_{r=1}^{n_i} \sum_{s=1}^{n_{r_j}} t_{R_{s_i,j,s}} + \sum_{r=1}^{n_i} \sum_{s=1}^{n_{r_j}} t_{S_{s_i,j,s}} \right]
\]

(17)

It can be prescribed as an object function that (17) should be minimal:

\[
t_{\text{opt}} = \min \left[ \sum_{r=1}^{n_i} \sum_{s=1}^{n_{r_j}} t_{t_{E_{r_i,j,s}}} + \sum_{r=1}^{n_i} \sum_{s=1}^{n_{r_j}} t_{K_{r_i,j,s}} + \sum_{r=1}^{n_i} \sum_{s=1}^{n_{r_j}} t_{R_{s_i,j,s}} + \sum_{r=1}^{n_i} \sum_{s=1}^{n_{r_j}} t_{S_{s_i,j,s}} \right]
\]

(18)

On base of (18) it can be concluded, that the value of the object function in case of supply of the constituents for the maintenance from a transportation in storage is depend on

- the number of the transporters being involved,
- number of the constituents being transported, and on
- the number of the storages \( n_s \),
- the number of the compositions and demolitions of unit packages \( n_{s_k} \),
- the number of applied commissions \( n_{s_k} \),
- the number of applied storages \( n_{s_k} \),
- the number of transportations \( n_i \), per transporters and constituents \( n_{s_k} \),
- the time demand of given logistical activities in case of given transporters and constituents.

### 3 Real time necessity

The real time necessity of the logistical activities are added by two parts:

- the real technological time of the logistical activity,
- the waiting times for facilities, equipment, which are necessary for the given logistical activities and perhaps also the waiting time for the maintenance object.

All of the elements in (11) can be written as

\[
t_{a_{u,j}} = t_{a_{u,j}} + t_{a_{u,j}}
\]

(19)

where

\( t_{a_{u,j}} \) - at given maintenance activity the real time for the logistical activity \( \alpha \) in case of the product \( J_r \) at the
transporter \(i_r\),

\[
t'_{\alpha, i_r} \quad \text{at given maintenance activity the technological time for the logistical activity } \alpha \text{ in case of the product } j_r \text{ at the transporter } i_r,
\]

\[
t^*_{\alpha, i_r} \quad \text{at given maintenance activity the waiting time for the logistical activity } \alpha \text{ in case of the product } j_r \text{ it the transporter } i_r.
\]

Bellowing to the information of (18) the followings can be started:

\[
t_{\alpha, i_r} = t'_{\alpha, i_r} + t^*_{\alpha, i_r} = \min \tag{20}
\]

or

\[
t^*_{\alpha, i_r} \rightarrow 0 \tag{21}
\]

\[
t'_{\alpha, i_r} = \min \tag{22}
\]

If the assurance of the necessary constituent bellowing to a given maintenance activity a carried out by renovation of the dissembled constituent at an external place, then for the determination of the time of the demanded of delivery the followings should be taken into consideration: the time necessity of the logistical activity being proceeded between the object under maintenance and the renovation place \((t_B(i_r, j_r))\), the real time of the renovation. In this case the time for the demand of delivering:

\[
t_{HR2} = t_{HR1} + t_B(i_r, j_r) + t_f(i_r, j_r) \tag{23}
\]

If the maintenance activity is proceeded by the remanufacturing of the necessary constituent the total manufacturing time should be taken into consideration \((t_G(i_r, j_r))\):

\[
t_{HR3} = t_{HR1} + t_G(i_r, j_r) \tag{24}
\]

The materials, facilities the necessary times of demands of deliveries can be written in a similar way by using (18); (23) and (24). By using (1) let us denote the necessary times for carrying out the maintenance activity:

\[
t_{\alpha} = t_{MA} + t_{HA}; \quad \text{for materials,} \tag{25}
\]

\[
t_{sx} = t_{MR} + t_{HR}; \quad \text{alkatrészekre vonatkozóan,} \tag{26}
\]

\[
t_{ax} = t_{ME} + t_{HE}; \quad \text{eszközökre vonatkozóan,} \tag{27}
\]

\[
t_{ao} \quad \text{is the time for demand of delivery.}
\]

Let us denote the time when it turns out the maintenance has to be proceeded by \(t_k\).

So the possible start of the maintenance activity at the object is

\[
t_{ Indo} = t_k + \max \{t_{sa}, t_{sa}, t_{sa}, t_{sa} \} \tag{29}
\]

where

\(t_k\) - is the time of occurrence of the demand of the maintenance.

4 Conclusion

In case of the time parameters of the maintenance logistics main factors are considered. The time factors to be connected with the demand of delivery of the necessities are investigated. In the system of the demand of delivery for the maintenance activity all the time new material and facility transportation is taken into consideration. The mathematical model of the real time necessity of the logistical activities has been formulated.

References:


