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OPTIMIZATION OF SHUNTING PROCESS AT A PASSENGER COMPLEX

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Abstract *–The technology of passenger station includes the flow of operations to service the movement of trains and shunting activity to the technical station representing a common railway complex providing the best service to passengers and using the available technical means. The shunting process at a passenger station consists of activities such as handling trains, taking them out of the technical station and their placement on tracks according to the train assembling plan. The paper examines the work of shunter teams and how the number of teams required to serve the passengers railway complex is determined. The study is aimed at possible improvement of shunting process based on a number of selected indicators theoretically worked out: the number and duration of shunting movements per duty; the number and duration of isolated movements; the stay and utilization of shunting teams; the relative occupancy of station tracks. The implementation of the current schedule for the movement of trains and the existing schedule plan for the work at the Sofia station was analyzed and a new one was developed to improve the work of the shunting teams. The developed new scheme of the shunting process ensures reducing the relative employment of shunting teams and the duration of shunting movements.*

Keywords – shunting activity, passenger station, relative occupancy.

1. INTRODUCTION

Passenger railway complexes are built in large cities to serve passenger flows and train traffic. They include passenger stations with facilities for boarding, getting off and serving passengers; technical stations for technical inspection, maintenance, repair and equipment of passenger trains; sheds for stay of carriages and different categories of trains; in some cases there are also locomotive depots and shops for their repair [9]. The mutual location of passenger and technical stations and the specific construction of a throat between them determine the parallelism of train and shunting routes[1, 2]. The full flow of train handling and reduction of reverse train movements on the complex territory to a minimum depends on the layout of passenger railway complex facilities. Rail shunting at stations is an essential process providing continuous receptions and departure of trains, timely pushing to and pulling wagons out of the station, providing minimum time of stay on arrival and departure tracks by effective use of shunting equipment and in compliance with traffic and labour safety. The time required for trains to enter the station before the scheduled departure ensuring comfortable seating of passengers and timely clearing the arrival and departure tracks from trains having completed their run are considered. The improvement and optimization of shunting process is one of the most important tasks in the theory and practice of railway transport organization and management. To provide train traffic, shunting teams perform a significant amount of work and that is used as a basis to determine the necessary number of shunting teams on different shifts.

2. THEORETICAL STATEMENTS

To determine the number of shunting teams required for a given shift, it is necessary to consider the following indicators of shunting work at the station: the number of served passenger trains, the number and duration of isolated movements, the number and duration of shunting operations during the time on duty [5,7,10], the utilization of shunting teams and station tracks [3,6]. In addition, a number of factors have been taken into account: the relatively constant scheme of the shunting process related to the processing of passenger trains and their preparation for subsequent courses, the need for interaction between passenger and technical stations, as well as the location of various passenger train parks.

The duration of movements T_{trav} [min] is determined by the formula:

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$$T_{trav} = \sum_{i=1}^{n}[i * t_{trav,i}] \tag{1}$$

where:

i = 1,2,3…, n – – number of shunting movements;

$t_{trav,i}$ - travel time for the i[th] movement, [minutes].

The duration of isolated movements T_{is_trav} [min];

$$T_{is\_trav} = \sum_{j=1}^{J}[j * t_{is\_trav,j}] \tag{2}$$

where:

j = 1,2,3… J – number of isolated (empty) movements;

$t_{is\_trav,j}$ - travel time for the j[th] movement, [min].

The utilisation of shunting team is reported by the formula:

$$\chi = \frac{T_{work}}{1440 - T_{const}} \tag{3}$$

where:

T_{work} – time of shunting;

T_{const} – time of constant operations;

χ – utilisation of shunting team.

$$T_{work} = T_{trav} + T_{is\_trav} \tag{4}$$

The utilization of shunting team can be reported by the work schedule for each shunting operation. The duration of shunting movements, their number, and the isolated run can be calculated by the schedule of pulling trains out of the station and pushing them to the technical area and then back from it to the passenger station.

To determine the number of shunting teams, it is necessary to consider the total working time of shunting for a shift and depending on the desired time of utilization, to find out the required number.

$$N_{shun} = \frac{T_{work\_sm}}{(1440 - N_{const}) * \chi} \tag{5}$$

The rate of utilisation can be set in the range of 0.75 to 1.00, the latter showing that the shunting team will not have any downtime at disposal. However, this value is not reasonable because a train delay or a carriage breakdown could occur at any time imposing the need of replacement.

The utilisation of station tracks is determined by the expression:

$$\chi_{track} = \frac{\sum(T_{util} + N_{tr}.t_{add})}{(1440 - T_{const\_tr})U_{track}} \tag{6}$$

where:

T_{util} - time when trains are placed on the tracks;

U_{track} - number of tracks;

t_{add} - additional time (accepted to be 10 minutes per train);

N_{tr} - number of arriving and/or departing trains.

T_{const_tr} - time for operations, which are not related to the activities under this study (e.g. passing of a freight train).

In this case the utilisation of arrival and departure tracks is used as a criterion to improve work organization as shunting optimization includes the number and type of shunting movements, which reflects on track utilisation and it increases. The rate of track utilisation is significantly less than the shunting team employment because there are periods with a small number of departing or arriving trains and without trains staying on the tracks. The utilization is usually determined in the morning or afternoon when there is a great number of trains departing from and arriving in the capital of Sofia to serve suburban and long-distance traffic [4,8].

3. CASE STUDY SOFIA PASENGER STATION

Sofia railway station (Sf) is the biggest passenger station in Bulgaria that is connected with the railways of Serbia and Greece, the town of Varna, the suburban line to Bankya and the technical station of Nadezhda through its western station throat and with the railways of Turkey, the freight station of Sofia and the locomotive depot through its eastern throat. All that defines the complexity of station throats, especially in the direction to the technical station of Nadezhda.

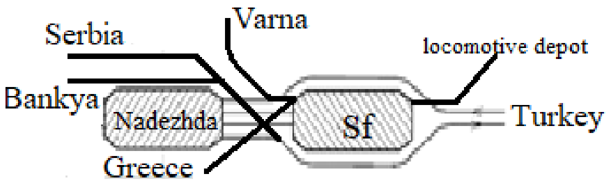

Fig.1. Scheme of Sofia passenger and Nadezhda technical stations

That leads to necessity of parallel routes and simultaneous provision of receptions and departures of trains and shunting operations for pulling trains out of Nadezhda technical station (the distance between the two stations is 1.200 km) as well as replacement of rolling stock (carriages and locomotives) to assemble different trains. The number of served trains is relatively constant and is calculated by Schedule II - 24 for trains that start or end their routes of running at the station. The multiple units (EMU, DMU) move independently to the technical area for external washing, technical inspection and equipment.

The arriving and departing passenger trains that are served at the station of Sofia amount to 115 during the day and 61 for a night shift. The trains pushed to the technical area of Nadezhda are 27 during the day and 14 for a night shift. The Technical Station of Nadezhds is served by station shunters of Sofia Passenger Transport Department at Sofia Station.

The schedules of rail shunting operations are developed before entry into force of the new Train Traffic Schedule and in case of changes in work organization. The rail shunting at Sofia station is carried out by 3 shunting teams during the days and 2 shunting teams on night shifts.

Based on the plan of train receptions and the developed schedules for shunting operations, a Round-the-clock schedule (RCS) is graphically developed once a year before entry into force of the new Train Traffic Schedule. The RCS graphically reflects the sequence and duration of performance of all train handling operations and defines the rules of using technical facilities at the station (Table 1).

Tab. 1. Symbols in the Round-the-clock schedule

Symbol	Meaning
	Track occupation by an arriving train
	Track occupation by a departing train
	Track occupation by a train
	Train handled by shunting team 1
	Train handled by shunting team 2
	Train handled by shunting team 3
	Train pushed to the depot
	Train pulled out of the depot

The developed new organization of shunting activity includes the following changes in Schedule II - 24: use of the 4th headshunt in order to relieve the 1st and 2nd headshunts; increase of shunting operations performed by the team on night shift in the interval 5:30-7:00 instead of pushing to the station in the interval 7:00-8:00; pulling out two trains connected in one to the technical station, which saves one operation and isolated shunting for each similar case; change in pushing to certain tracks so that two trains can be placed on one track but depart in different directions.

Based on the changes made and the types of shunting activities performed by shunting teams, a new organization has been introduced and a new Round-the-clock schedule (RCS) has been developed for daily work (Fig.2) and night shifts.

Table 2 shows the utilisation of shunting teams and arrival and departure tracks at the passenger station, which is used to assess the new organization of shunting work and the previously existing one.

Tab. 2. Round-the-clock schedule – daily work utilisation χ

	Daily old	Daily new	Night old	Night new
Shunting team 1	0,95	0,89	0,96	0,90
Shunting team 2	0,96	0,84	0,95	0,89
Shunting team 3	0,95	0,83		
Tracks	0,56	0,57	0,57	0,59

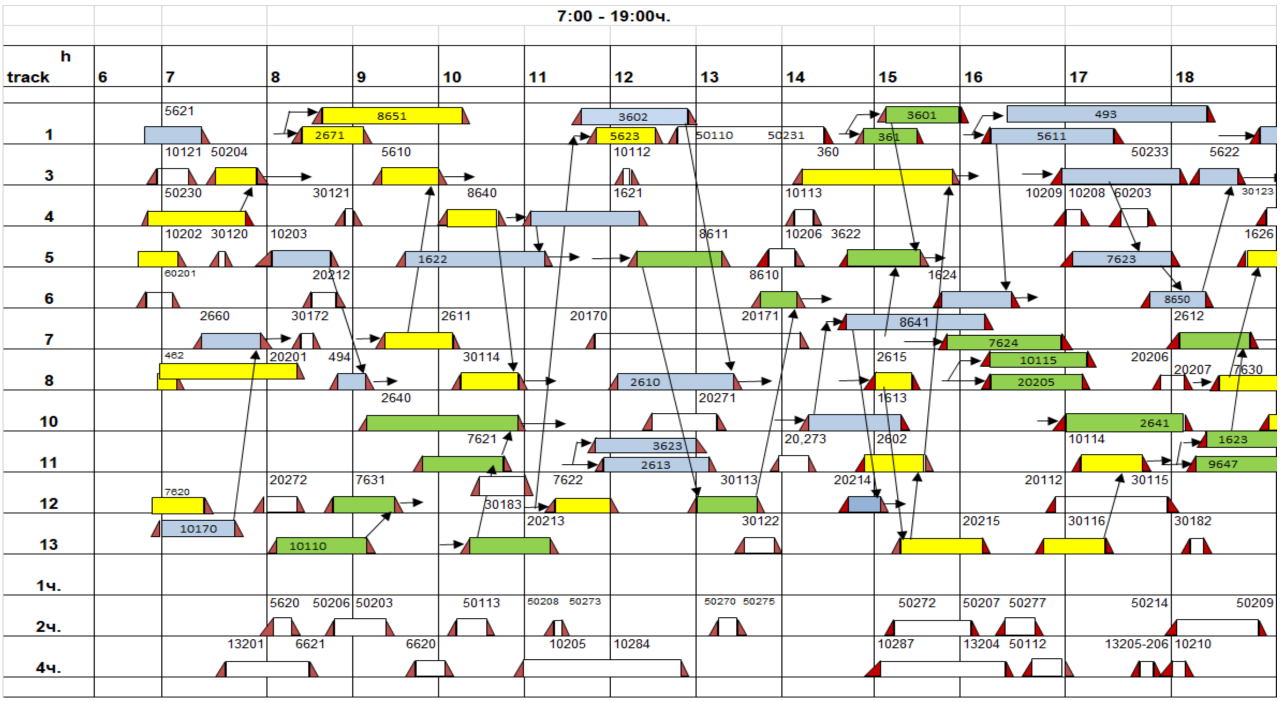

Fig.2. Round-the-clock schedule

4. CONCLUSION

The purpose of developed new organization is to optimize the activities of shunting teams by reducing their workload. In recent years the number of passengers using railway transport has decreased and, accordingly, the number of carriages in a train has also been decreased. That makes possible to push two trains from the technical station to the passenger station and in reverse using one shunting operation for the trains ending their travelling at the passenger station.

In the examined specific case Shunting team 3 works only during the day, but depending on the planned activities, shuntimg teams might work 8 hours or serve several neighboring stations. With the change in Schedule II - 24, the utilisation of tracks is also taken into account and used as a criterion to make assessment of the implemented optimization. The change could be estimated as successful if the track utilisation is not increased by more than 0.05. The theoretical formulation presented in this paper can be applied not only to passenger stations, but also to stations with intensive shunting activities.

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