Road Intersection Improvement – Main Step for Emission Reduction and Fuel Economy

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Abstract. This article demonstrates the changes made in the intersection model using PTV Vissim have an impact on reducing an amount of GHG and fuel consumption. One of the most problematic intersections in Namangan, Uzbekistan, was selected and traffic flow during peak hours was studied in order to prepare the simulation of the intersection. The article offers two types of solution as so to lessen the amount of toxic gases and fuel consumption. In the first solution, the situation was improved by optimizing the phase of the traffic light and by changing the cycle duration. The second solution was to reduce the amount of toxic gases and fuel consumption from vehicles by changing the geometric dimensions of the intersection. After the implementation of both solutions, the current state of LOS was raised from D to A level.

1. Introduction

Avoiding the traffic congestion on motorized roads is one of critical human problems. World population is losing their priceless time and their money on everyday transport trips from B to A points. In addition, commuters and also people living in dense city center are unconsciously harming their health with toxic gases emitted from transports into atmosphere [1-13]. Nowadays vehicles, which are under exploitation, pollute the atmosphere very much, for example: if one vehicle consumes 10-12-liter gasoline it exhausts 25 kg different harmful chemical compounds, therefore one vehicle consumes about 4 tons oxygen per year [2]. Exhaust gases of the engine comprise more than 500 harmful organic compounds such as carbon monoxide (CO), carbon dioxide (CO2), volatile organic compounds (VOCs) or hydrocarbons (HCs), nitrogen oxides (NOx). Gases emitted by cars stopping at the traffic light are contributing to global warming [3]. If we implement some changes at intersections, actually the phases of the traffic light and then, the time spending for no use at traffic lights might be corrected. Traffic congestion increases vehicle emissions and degrades ambient air quality, and recent studies have shown excess morbidity and mortality for drivers, commuters and individuals living near major roadways [4]. Tashkent, Uzbekistan - In January 2019, Yandex began to show traffic jams in Uzbekistan. After 11 months, the company summed up the results of the year and found out how congestion in the capital of Uzbekistan was changing. The average traffic congestion score ranged from 4.5 in August to 5.8 in April. The most favorable time for motorists was summer, and the hardest month was April, which hit the spring peak of morning traffic jams - 7 points.

2. Methods For Road Intersection Improvement

The intersection of the streets in Namangan city center I. Karimov (street-1), Oromghox (street-2), Sanoatchilar (street-3) were selected (further in the text is given as an intersection) as an object for research. The general indicators of the intersection in the current situation are as follows: the width of
the carriageway 22 m; the number of lanes is 6; the installed traffic light’s phase number is 2; cycle duration 46 sec (Figure 1). In phase 1, straight movement is only allowed to move from street-2, in phase 2, is allowed to move from street-1 to the street-1 and street-3 (Figure 2).

The number of cars crossing the intersection at rush hour in the morning is 6055 cars / hour, as shown in Table 1.

| Street names | Total    |    |    |    |
|--------------|----------|----|----|----|
| street-1 A   | 716      | 1378| 77 | 28 | 2199 |
| street-1 B   | 162      | 291 | 1378| 70 | 1901 |
| street-2     | 927      | 271 | 375| 70 | 1643 |
| street-3     | -        | -  | 312| -  | 312  |
| Total        | 2467     | 1278| 2142| 168| 6055 |

**Figure 1.** General view of the intersection

**Figure 2.** General flow diagrams of traffic lights which is installed at the intersection

| Street names | Total    |    |    |    |
|--------------|----------|----|----|----|
| street-1 A   | 716      | 1378| 77 | 28 | 2199 |
| street-1 B   | 162      | 291 | 1378| 70 | 1901 |
| street-2     | 927      | 271 | 375| 70 | 1643 |
| street-3     | -        | -  | 312| -  | 312  |
| Total        | 2467     | 1278| 2142| 168| 6055 |
A model of the current state of the intersection was created using the above data and PTV VISSIM program, and the results obtained are shown in Table 2 and Figure 3 respectively.

**Table 2.** The information about the fuel consumption and the amount of toxic gases emitted by vehicles into the atmosphere as a result of traffic jams at the intersection during the rush hours of the day

| Emissions volatile organic compounds, gram | 2573.8 |
| Emissions Nitrogen oxides, gram | 2160.7 |
| Emissions carbon monoxide, gram | 11105.7 |
| Fuel consumption, liter | 601.4 |
| LOS (Level of service) | C |

**Figure 3.** Visual view of the current state model of the intersection

Two different types of methods are used in order to improve the flow of cars in the intersection in this research.

3. **Methods for Fuel Consumption Reduction**

**Figure 4.** Traffic lights operation diagram
The effect of reinstalled traffic lights' phases to traffic at the intersection has been modelled by PTV Vissim software then the final results has been given in Table 3 and 4.

**Table 3.** The information about the fuel consumption and the amount of toxic gases emitted by vehicles to the atmosphere as a result of traffic jams at the intersection during the rush hours of a day

|                       | gram     |
|-----------------------|----------|
| Emissions volatile organic compounds | 1530.7   |
| Emissions Nitrogen oxides | 1285.03  |
| Emissions carbon monoxide | 6604.7   |
| Fuel consumption, liter | 357.6    |
| LOS                    | B        |

**Table 4.** The information about the fuel consumption and the amount of toxic gases emitted by vehicles into the atmosphere as a result of traffic jams at the intersection during the rush hours of the day

|                       | gram     |
|-----------------------|----------|
| Emissions volatile organic compounds | 1336.40  |
| Emissions Nitrogen oxides | 1121.23646|
| Emissions carbon monoxide | 5766.3   |
| Fuel consumption, liter | 312.27   |
| LOS                    | A        |

From the point of view of traffic safety, the duration of the cycle should not be allowed to exceed the norm, as drivers may have to wait a long time for the permissible signal, as a result the amount of toxic gases emitted from cars into the atmosphere and fuel consumption may increase. If the calculated value of the cycle of the stoplight phase exceeds the specified second, it is necessary to reduce the duration of the cycle by increasing the number of moving parts approaching the intersection, prohibiting certain maneuvers, reducing the number of adjustment phases, arranging fast currents in two or more phases. However, it is not advisable to take the duration of the cycle to be less than 25 seconds [12]. Taking into account the above data, in this article, the 2nd model of the intersection was created to improve the service quality (LOS) of the intersection using the PTV VISSIM program. The most alternative phase of traffic lights installed at the intersection, and changes were made to the geometric dimensions of the intersection in order to reduce the amount of toxic gases and fuel consumption by increasing the mobility of vehicles at the intersection, that is the number of carriageways lanes on street-1 A and B was increased from 6 to 8, as a result of which the width of the carriageway was increased from 22 m to 29 m, the direction of movement and phase of traffic lights were unchanged as shown in Method 1. Based on the above data, a model of the intersection was created using the PTV VISSIM program and the following results were obtained (Figure 5).
4. Results and Discussions

The results of the study are presented in the table below (Table 5). From the table, it can be seen that the current performance of the intersection has been improved by the first and second methods. Comparing the data obtained, one can see a significant difference between the current and final status indicators. For example, in the current situation, the fuel consumption of cars is 601.04 liters, in the model created by Method 1 fuel consumption of cars is 357.6 liters, in Method 2 fuel consumption of cars is 312.27 liters, and the amount of toxic gases emitted from cars is reduced by almost 50%. Both methods are created by simulation with software. The main reasons for this are the phases of the traffic lights installed at the intersection and the changes in the geometric dimensions of the intersection. At the same time, the geometric dimensions of the intersection and the alternation of the traffic light phases have led to an increase in the speed of cars moving at the intersection and a reduction in waiting time at the intersection and the length of traffic. As a result, changes have been affected to reduce emissions of toxic gases and fuel consumption.

**TABLE 5.** The information about the fuel consumption and the amount of toxic gases emitted by vehicles into the atmosphere as a result of traffic jams at the intersection during the rush hours of the day

|                     | The result of basic model of intersection | The result of the first model of intersection | The result of the second model of intersection |
|---------------------|------------------------------------------|---------------------------------------------|---------------------------------------------|
| Emissions volatile organic compounds gram | 2573.8                                   | 1550.7                                      | 1336.40                                      |
| Emissions Nitrogen oxides gram | 2160.7                                   | 1285.03                                     | 1121.23646                                    |
| Emissions carbon monoxide gram | 11105.7                                  | 6604.7                                      | 5766.3                                      |
| Fuel consumption liter | 601.4                                    | 357.6                                       | 312.27                                      |
| LOS                  | C                                        | B                                           | A                                           |

5. Conclusions

The results of the study are presented in the table above (Table 5). It can be seen from the table that the current performance of the intersection was improved by two methods, and the quality of service at the intersection was improved from C to A. Toxic emissions and fuel consumption from cars at the intersection have been reduced by almost 50%. Models created using the PTV VISSIM program have been proposed to increase the capacity of the intersection and reduce its impact on the environment and the economy, these models were found to be effective and put into practice.

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