



## PROBLEMS OF ENERGY REDUCTION DURING THE HOT-MIX ASPHALT PRODUCTION

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**Abstract.** The paper presents selected factors that affect the energy consumption during the technological process of hot mix asphalt production and the level of fuel consumption depending on the moisture content of mineral aggregates located on the plant site. Basing on earlier investigations, measurements and analyses, as well as on working experience in organization and control system to exclude unnecessary energy loss during hot mix asphalt production, the authors reviewed the available worldwide literature on the topic. Attention was directed to the mathematical-physical dependence and the results of engineer measurements regarding the authors' own research. Between 2007–2009 consumption of fuel and aggregate moisture content on the plant sites and hot mix asphalt production parameters were measured to verify the analyses and conclusions found in literature. The authors focused on the problem of the production capacity relating to the consumption of fuel. This paper is an attempt to define the possibility of energy-consumption reduction during hot mix asphalt production through suitable work organization or technical solutions. The paper presents the discussion over the authors' own results of investigations as well as results of analyses of other authors in the concerned field.

**Keywords:** energy, moisture, production, hot mix asphalt, aggregate, fuel, consumption.

### 1. Introduction

The paper continues and widens the subject of the paper published in the Proceedings of 10<sup>th</sup> International Conference in Vilnius (Lithuania) in May 2010 (Grabowski, Janowski 2010).

The object of the paper is to recognize the influence of selected factors on energy consumption during the hot mix asphalt (HMA) production and to define the level of fuel consumption depending on aggregate moisture in relation to the organization of HMA production process. The paper is based on the results of the authors' own research conducted for several years.

The research conducted since 2007 proved that the moisture of fine aggregate and the efficiency of the asphalt mixing plant (AMP) producing HMA have the highest impact on energy consumption during HMA process.

Basing on results of own measurements and research, the current status of knowledge was reviewed, with special emphasis on: theoretical, mathematical-physical aspects of fuel consumption and energy parameters; changes of aggregate moisture stored in the AMP; influence of air temperature and precipitation. The current practical

knowledge and results of observations conducted by the engineers throughout the world are reviewed.

First stage of measurements and research was conducted between March 13<sup>th</sup> and April 30<sup>th</sup> 2007. The results formed the initial set of data which gave an impulse to introduce organizational changes in HMA production process. Between 2008–2009, new organizational solutions were implemented to lower usage of heating oil during HMA production and placing process. The above mentioned implemented solutions were further on evaluated by means of measurements. The paper below concentrates on the problem of energy reduction.

### 2. Knowledge review

Thesis that the aggregate moisture is a main factor influencing the level of energy consumption in the HMA production process was formulated by Ang *et al.* (1993). They presented the results of investigation over energy consumption process in two different AMP located in Singapore, which used granite aggregate in their production process. Tests conducted by Ang *et al.* (1993) in natural and laboratory conditions proved that the aggregate

moisture is a main factor deciding on the level of energy consumption in the whole production process.

A typical value for aggregate moisture content is 5% by mass meaning that for a nominal production rate of 320 000 kg/h of mix, 15 875 kg/h of H<sub>2</sub>O must be removed (Hobbs 2009).

It has also been noticed that the energy consumption varies significantly with the season of the year. It has been explained by the changes in the size of the HMA production as well as the atmospheric changes. It should also be noticed that the aggregate storages were not equipped with any type of cover protecting from atmospheric falls. It has also been underlined that the manager of AMP had no control over the level of HMA production. Ang *et al.* (1993) measured the aggregate moisture located on the storage of the two AMP and determined the implied upper moisture limits of field aggregate. They also stated that the short atmospheric falls lead to an important increase of the aggregate moisture.

Ang *et al.* (1993) presented a few mathematical dependencies (equations) describing energy consumption. The energy consumption for drying the aggregate mix,  $E_{dry}$ , was calculated from:

$$E_{dry} = M_a \left( \frac{W}{100} \right) (70C_p + C_l) + M_a (70C_a), \quad (1)$$

where  $M_a$  – the total aggregate weight, kg;  $W$  – the overall aggregate moisture content, %;  $C_p$  and  $C_l$  – respectively, the specific heat capacity and latent heat capacity of water, J/kg°C;  $C_a$  – the heat capacity of granite aggregate, J/kg°C.

The energy consumption for heating the aggregate mix above the water boiling point,  $E_{heat}$ , was calculated from:

$$E_{heat} = M_a C_a (T - 100), \quad (2)$$

where  $T$  – temperature of the aggregate mix, °C (from 150 °C to 170 °C).

Both estimates of  $E_{dry}$  and  $E_{heat}$  are useful energy requirements.

The reduction in energy requirements, depending on aggregate moisture was described in the following equation:

$$dE_{dry} = M_a \left( \frac{dW}{100} \right) (70C_p + C_l), \quad (3)$$

where  $dW$  – the reduction in overall aggregate moisture content, %.

On the basis of the above equations Ang *et al.* (1993) stated that only for drying and heating of aggregate to 100 °C, with the average aggregate moisture between 3.12% and 3.99%, 3.68 l to 4.28 l of heating oil per ton of produced HMA are consumed. The authors also showed the percentage share of particular stages of work in AMP in consumption of heating oil. Table 1 shows that drying of the aggregate mix accounts for the largest consumption share.

**Table 1.** Breakdown of diesel fuel consumption (Ang *et al.* 1993)

	Continuous plant, %
Drying of aggregates	47
Heating of aggregate mix	12
Heating up the drum	3
Convective loss	2
Waste heat	36
Total	100

Based on Eq (3), Ang *et al.* (1993) found that the reduction in aggregate moisture of about 3% reduces the energy consumption in drying by about 55–60%.

Similar topics related to energy consumption in AMP have also been shown in the papers of Spuziak (1995). The aggregate moisture on the plant site is, according to Spuziak (1995), function of the size of the grain, the method of protection, topography of the terrain, and weather conditions. He has discovered that the same aggregate has double difference in moisture depending on the different storage place. It resulted from the method of draining of the storage place, the level of contamination of aggregate with sub-fraction and the weather conditions. The aggregate stored without any type of roof or cover was characterized by moisture inversely proportional to grain diameter. Spuziak (1995) stated that fine grain and dust aggregate require roofed storage place. Aggregate fractions below 5 mm or – in case of bad terrain conditions – below 8 mm require roof cover in the storage. Spuziak (1995) presented also the equation enabling the calculation of the saving in energy consumption during the drying process due to the lowering of the average aggregate moisture stored under roof.

Saving in energy consumption (the so-called economic effect) was described by the following equation:

$$E_e = \frac{z_g [(100 - t_z)c_w + r + c_p(t_s - 100)]}{w_0 \eta} \Delta w c z_0, \quad (4)$$

where  $E_e$  – is the economic effect, PLN;  $z_g$  – the grit content in the HMA, kg;  $t_z$  – the temperature of cold aggregate, °C;  $c_w$  – the specific water heat, J/kg°C;  $r$  – the water vaporization heat, J/kg;  $c_p$  – the specific water vapour heat, J/kg°C;  $t_s$  – the temperature of the fumes, °C;  $w_0$  – the heating value of fuel, J/m<sup>3</sup>;  $\eta$  – the coefficient of heating efficiency (computed acc. to a different equation);  $\Delta w$  – the change percentage of moisture;  $z_0$  – the price of heating oil, PLN/m<sup>3</sup>.

One should pay attention to the equation presented by Brock and Mize (1980) enabling to calculate the theoretical size of the AMP production (i.e. the drum of the dryer):

$$M_a = \frac{0.95Q}{C_{p_a}(T_0 - T_i) + M_{H_2O}H_{H_2O}}, \quad (5)$$

where  $M_a$  – the weight in pounds per hour of asphalt – aggregate material, lb/h;  $C_{p_a}$  – the specific heat of the asphalt – aggregate material, BTU/lb°F;  $T_0$  – the exit

temperature of product, °F;  $T_i$  – the entry temperature of the asphalt – aggregate material, °F;  $M_{H_2O}$  – the percentage of water per pound of asphalt – aggregate material;  $H_{H_2O}$  – the heat required to raise water temperature and evaporate it per pound of water, BTU/lb;  $Q$  – the heat per hour, BTU/h, as calculated below for the recirculation system:

$$Q = mC_p\Delta T, \quad (6)$$

where  $m$  – the volume of the gases in cubic feet per hour, ft<sup>3</sup>/h;  $C_p$  – the heat capacity of the gases at constant pressure, BTU/°F-ft<sup>3</sup>;  $\Delta T$  – the change in temperature in degrees, °F.

Eq (5) includes the influence of moisture of stored aggregate on the production capacity of AMP. It shows that for greater and smaller percentages of water and higher and lower temperature parameters, higher and lower production rates will be realized.

Theoretical and practical aspects of the AMP energy consumption were analysed by Bunz and Solbach (1981). The heat energy  $Q_N$ , necessary for drying and heating of the asphalt aggregate material, was described by the following equation:

$$Q_N = m_M \left[ c_M(t_2 - t_1) + \frac{w}{100 - w}(i_u - i_w) \right], \quad (7)$$

where  $m_M$  – the weight of wet aggregate mix, kg;  $c_M$  – the average proper heat of the aggregate mix, kWh/kgK;  $t_1$  – the temperature of stored aggregate, °C;  $t_2$  – the temperature necessary for heating of the aggregate, °C;  $w$  – the average moisture of the aggregate, %;  $i_u$  – heated steam enthalpy in  $t_2$ , kWh/kg;  $i_w$  – enthalpy of water in  $t_1$ , kWh/kg.

Additionally, the amount of heat necessary for heating specific amount of water, resulting from the level of aggregate moisture, was described by the following equation:

$$\Delta Q = \Delta m_w [c_w(t_s - t_1) + r], \quad (8)$$

where  $\Delta m_w$  – is the additional amount of water, kg;  $c_w$  – is the specific heat of water, J/kg°C;  $t_s$  – boiling temperature of water, °C;  $t_1$  – external temperature, °C;  $r$  – heat of water vaporization, J/kg.

Bunz and Solbach (1981) presented the dependency graph of heating material and aggregate moisture. They stated the less moisture the lower the energy consumption was.

Main conclusions deriving from literature are as follows:

- every 1% of total composite moisture change represents a 10% change in fuel requirements (Young 2008);
- fewer AMP turns-off in the production of HMA mixture result in less energy consumption. The start and stop of production versus the continuous

production raises actual fuel consumption up to 20–35% (Young 2008);

- an increase in 1% moisture in a ton of aggregate can result in an additional 0.6 l of fuel being consumed to evaporate it. At 6% moisture, 4 l of fuel are required to dry 1 t of aggregate. Once dry, 3 l of fuel are required to heat the aggregate to 150 °C meaning that more energy is used in drying the aggregate than in heating it;
- during the drying process more energy consumption is required to dry and heat saturated mineral materials. Mineral particles of different size absorb different amount of moisture (Ang et al. 1993);
- with a reduced mixing temperature from 165 °C to 115 °C and a reduced moisture content of the aggregates from 4% to 2% the energy savings are approx 2.5 kg of fuel per ton of asphalt (Jenny 2009);
- the work process concept (e.g. a concrete plant and 3 asphalt plants fed by an aggregate storage system with a capacity of 23 000 m<sup>3</sup> and 30 silos) reduces the moisture content of aggregates to less than 2% and this reduction of 2% in the moisture content leads to an energy saving of 1.5 kg of heating oil per ton of asphalt (Jenny 2009).

The required temperature of the produced HMA mixture, thus the energy consumption, depends not only on the moisture and temperature of mineral materials, fuel quality (especially fuel oil), operator's actions, but also on the AMP structure (burner, drying drum, bitumen system) (Sivilevičius 2011).

The structural changes in bitumen batching system (for example frequency converter of the bitumen pump's electric motor, modern control systems) allow more accurate pouring of bitumen into a weigh bucket as well as reducing heat energy consumption for free bitumen flow (Bražiūnas, Sivilevičius 2010). Also the use of the elements of automatic control helps to make the operation of system's equipment more precise and energy-effective.

### 3. Program of own investigations and measurements

Results from 2007 in AMP in Benninghoven (with capacity of 240 t/h) presented by Grabowski and Janowski (2007) were the inspiration for taking the decision, in 2008, to story only aggregate with fraction above 5 mm on the AMP site. The experiments done so far showed little effect of moisture of those fractions on the fuel consumption whilst the HMA production process.

The research was conducted in AMP in Benninghoven, that was working exclusively for two big construction contracts of expressways, each several dozen kilometres long. It should be underlined that the contract managing director had influence on the schedule of AMP and breaks in the production, therefore, thanks to proper management, the important cost reductions could be implemented. It was planned to produce 60 000 t of HMA within 3 month period during autumn season in which heavy rainfalls occur quite often.

Authors' own investigation showed that the amount of stored aggregate at AMP is an important factor pending on costs of the production process. The production was stopped during long and intensive rainfalls; having little amount of stored aggregate, only a small amount of the material succumbed to moisture. As a result, higher costs of fuel concerned only the small amount of stored material. It was a new element of production organization at AMP, which was contingent upon the possibility of deliveries and assurance of the continuity of AMP work. Therefore, the deliveries of fine aggregate with fraction 0/2 and 2/5mm started a couple of weeks before the beginning of the main production. The deliveries were organised in a way that max stored amount was 4000–5000 t. Most of the analyzed period the storage contained up to 2000 t of aggregate with fraction below 5 mm. Rational plan of deliveries organization which led to minimization of stored aggregate constituted an alternative to roofed storage dedicated for aggregate with grains below 5 mm (Grabowski, Janowski 2007; Spuziak 1995).

Second element, which aimed at improvement of production and placing of AMP, was the preparation and organization of work enabling placement of asphalt mix produced at maximum capacity of AMP (it has been assumed min 1500–2000 t of placed HMA per day). Such production cycle required perfect coordination of work at each stage and gave measurable benefits to fuel consumption.

#### 4. Research results and discussion

##### 4.1. Aggregate moisture content on the plant site

The laboratory test results of the moisture content of aggregate located on the plant site in 2007–2008 are shown in the Figs 1–3. The results give aggregate moisture for each fraction. Note: the moisture measurements of aggregate on the plant site were not carried out on the following days: 6, 4, 8, 9 and 28, 29, 40 of April 2007 (Fig. 1).

A short description of weather conditions in the analyzed period is necessary. Months: March and April 2007, October, November and December 2008 were periods of intensive precipitation and changing air temperature. Average precipitation in the months of late autumn 2008 was higher than that in the period of early spring 2007 (Figs 4 and 5).

The laboratory moisture tests of particular aggregate fractions on the plant site confirm that the aggregate moisture content of the 0/2 (0/5) fraction is ca. 1–3% higher than the others.

It was noticed during the routine control of laboratory test results in the period between 3<sup>rd</sup> and 20<sup>th</sup> of October 2008 that the aggregate samples for moisture test were not representative (Fig. 2). The samples were taken from the slagheap top layer or directly after rainfall, so the received results were distorted. This irregularity was eliminated by excluding the unrepresentative period from the analysis. Fig. 2 shows all the data to illustrate the fact by volume.

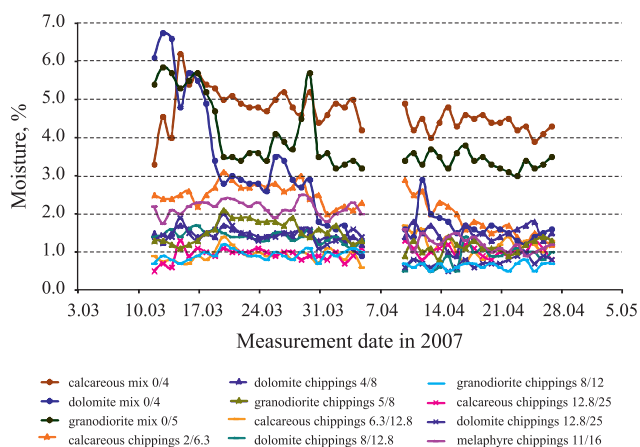


Fig. 1. The aggregate moisture content on the plant site in the AMP Benninghoven in 2007

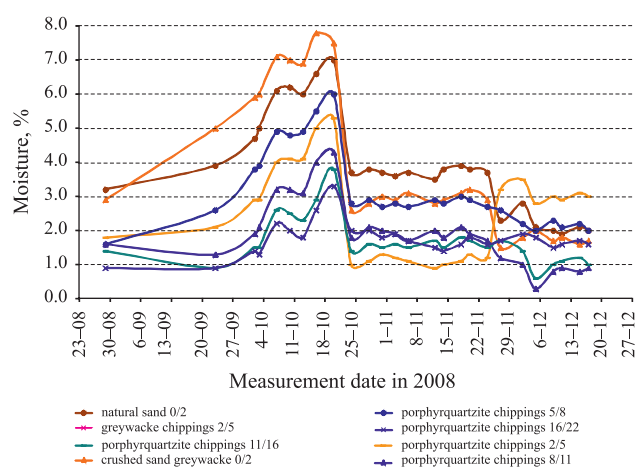


Fig. 2. The aggregate moisture content on the plant site in the AMP Benninghoven in 2008

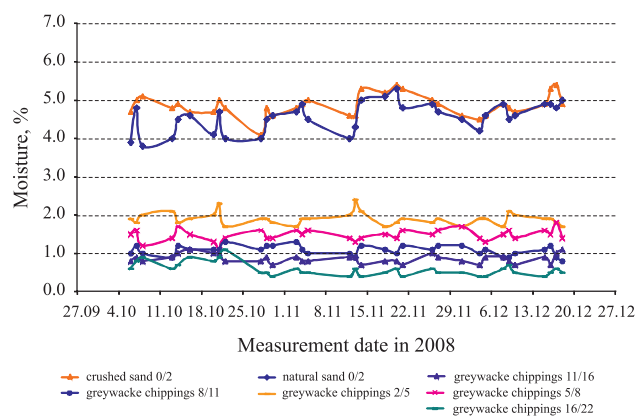


Fig. 3. The aggregate moisture content on the site in the AMP Ermont – Magnum 260 in 2008

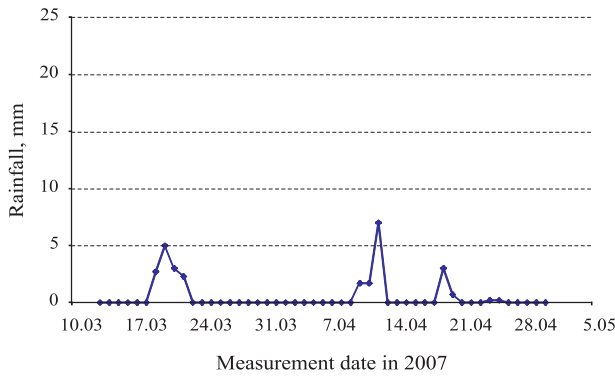


Fig. 4. Average daily precipitation on the plant site in the AMP Benninghoven in 2007

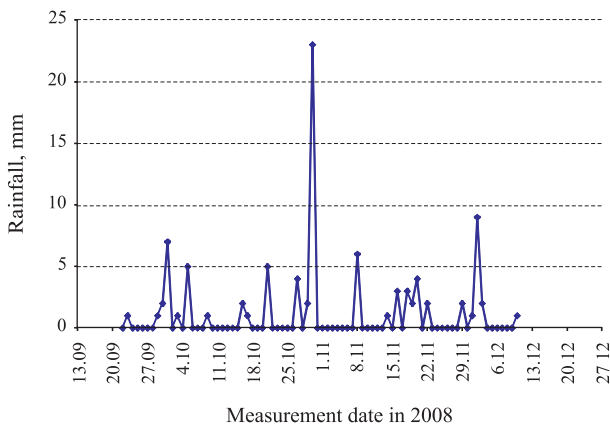


Fig. 5. Average daily precipitation on the plant site in the AMP Benninghoven in 2008

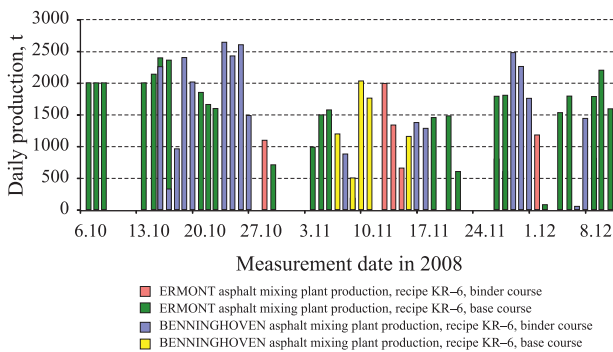


Fig. 6. Production capacity of the HMA

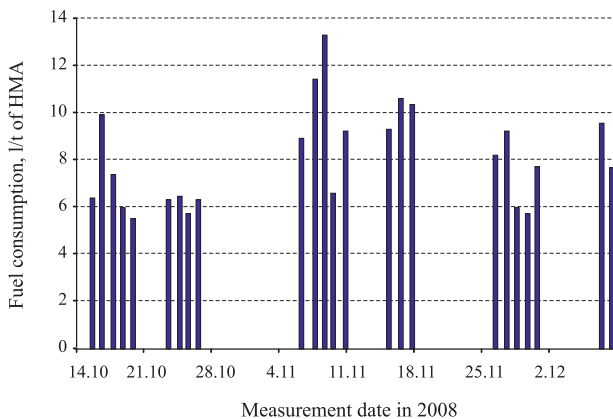


Fig. 7. Heating oil consumption per 1 t of produced HMA in AMP Benninghoven in 2008

From 25<sup>th</sup> of October 2008 the moisture of almost all aggregate fractions was lower than 3% with the exception of 0/2 mm natural sand (Fig. 2). For technological reasons natural sand 0/2 mm had to be stored on the site in a total amount of 18 000 t. Comparison of Figs 1 and 2 shows that before the implementation of new organizational solutions aiming at reduction of energy-consumption during the production process, the moisture of fine fractions (in 2007) fluctuated between 3–6%. The new work organization and preparation of the HMA production (MMA) in 2008 resulted in reduction of the moisture level below 3% in almost all the aggregate fractions with the exception of natural sand 0/2 mm.

Comparison of Figs 1, 2 and 3, presenting aggregate moisture on production site in AMP, with Figs 4 and 5, presenting average daily precipitation, shows that the moisture of aggregate with fraction above 5 mm varies between 1–3% with decreasing trend below 2% as far as the reduction of rainfall proceeded.

4.2. Production capacity of the HMA

The daily production by type of HMA and by type of AMP is shown in Fig. 6.

In 2007 the majority of HMA was produced in AMP Benninghoven, and in 2008 in AMP Benninghoven and AMP Ermont (Magnum 260) and was placed on the main route of expressway. Proportions of aggregate fractions in road foundation and in binding layer were close. Yet, different types of fractions were used.

4.3. Fuel consumption

Fig. 7 shows the heating oil consumption per 1 t of produced HMA in AMP in Benninghoven.

In Table 2, the authors compared the received results of heating oil consumption in the Benninghoven Asphalt Mixing Plant depending on the production size.

The results of measurements from 2008, shown in Table 2, are very similar to the results from 2007. It should be emphasized that in 2008 the fuel consumption during daily production of more than 2000 t was reduced below 6 l/t of HMA in comparison to a similar period in 2007.

The daily start-up of the AMP uses an immense amount of energy and has fundamental influence on fuel consumption during the daily production up to 1000 t of HMA, therefore this range of production is characterized by strong differences in the fuel consumption.

Table 2. Heating oil consumption in AMP Benninghoven depending on daily HMA production

Daily HMA production, t	Heating oil consumption per ton of HMA, l	
	in 2007 year	in 2008 year
0–1000	9.0–12.0	7.0–13.0
1000–1500	8.0–9.0	8.5–10.0
1500–2000	7.0–8.0	6.0–9.0
> 2000	6.5–7.5	5.5–6.5

#### 4.4. Limitation of negative influence of the increased aggregate moisture content

During the analyzed period the production of HMA in the AMP Benninghoven was continued in several day cycles. The heating oil consumption in l/t of produced HMA in 2008 is shown in Table 3.

The same analysis was done in 2007. The results are shown in Table 4.

Analyzing the time periods and the average HMA productions presented in Tables 3 and 4, it was noticed that for similar average HMA productions in 2007 and 2008 the average level of fuel consumption needed for production of 1 t of HMA is lower from 1–7 l in 2008 than in 2007. Just in one case where the average HMA production is 1392 t, the consumption level in 2007 is lower than in 2008. The reason of this exception seems to be almost 6 times smaller total HMA production in 2008 than 2007. For a similar average production of 1300–1400 t in 2007 the total production of HMA was 18 103 t whereas in 2008 only 3835 t.

Additionally, despite higher rainfall in October and November 2008 the fuel consumption during these few days was not as high as in the period from 10 to 18 March 2007 when the moisture content of aggregate located on the plant site was the highest.

Thus, the results of measurements, tests and analyses confirmed the reduction of energy-consumption of the HMA production in particular analyzed time periods as well as during the whole analyzed time.

The new organizational solution of the production, which was introduced in 2008 and aimed at reduction of the fuel consumption during the production and placement of HMA by means of decreasing the aggregate moisture content on the plant site, brought notable effects. The reduction in overall aggregate moisture content by about 1% in 2008 decreased the fuel consumption by about 1.6 l/t of HMA, i.e. by about 18% compared to 2007. The energy-consumption of the production was limited.

#### 4.5. Discussion over results of own investigations and results obtained by other authors

Conclusion drawn by Ang *et al.* (1993) that moisture is the main factor deciding on the level of energy consumption in the whole HMA production process is consistent with the authors' own results of measurements and analyses presented in sub-chapter 4.4 and in the previous publications (Grabowski, Janowski 2007; 2009; 2010).

The calculations using the test results have shown that the reduction of moisture content in the aggregate on the AMP site by about 1% has decreased the real oil consumption by about 18%. This confirms that the Eqs (1)–(3) are correct and allow us to get real results because according to them the reduction in aggregate moisture content by about 1% reduces the energy consumption in drying by about 15%.

However, a fundamental difference between conclusions of Ang *et al.* (1993) and conclusions of Grabowski

**Table 3.** Fuel consumption in litres of fuel per ton of the produced HMA in 2008

Time periods	Daily average HMA production, t	Total HMA production, t	Average level of heating oil consumption per ton of HMA, l/t
15–19.10.2008	1602	8009	6.3
23–26.10.2008	2301	9205	6.0
06–10.11.2008	1320	6604	9.0
15–17.11.2008	1278	3835	10.0
26–30.11.2008	1591	7954	6.7
06–08.12.2008	1130	2310	8.6

**Table 4.** Fuel consumption in litres of fuel per ton of the produced HMA in 2007

Time periods	Daily average HMA production, t	Total HMA production, t	Average level of heating oil consumption per ton of HMA, l/t
10–18.03.2007	1163	3490	15.5
19–30.03.2007	1580	18 965	7.5
31.03–6.04.07	1541	9249	9.7
10–28.04.2007	1392	18 103	8.7

and Janowski (2007; 2009; 2010) is based on the finding that, Managing Director of the contract or Manager of the plant can have direct impact on the level of HMA production, and consequently on the level of energy consumption in AMP.

The use of new solutions as well as organizational and technological regimes gives the real impact on the management of change of technical parameters, such as aggregate moisture on the AMP storage, heating oil consumption, and consequently gives measurable financial benefits without deteriorating quality of HMA product (e.g. reduction of heating oil consumption by 1–7 l/t of built-in HMA gives measurable financial benefits).

The research permitted to determine additional parameter, apart from the duration of atmospheric falls which were described by Ang *et al.* (1993), having the influence on the aggregate moisture on the slag heap, and that is the quantity of storage aggregate on slag heap. The production of HMA was stopped at periods of rainfalls. Having stored only a small amount of aggregate on the plant site, only that small amount succumbed to moisture and consequently higher consumption of heating oil regarded only that small amount. This factor is conditioned by new work organization, possibility of implementation of organizational changes, possibility of supplying materials and assurance of the continuity of the HMA production. Thanks to these findings, it has

been decided to implement organizational changes in the management of aggregate deliveries for HMA production. Consequently, whilst the contract realization the aggregate stored at the plant site without any type of roof had moisture below 3% what influenced the reduction of the heating oil consumption.

Referring to Spuziak (1995) that fine aggregate and dust require roofed storage, it should be noticed that alternative solution could be the proper management of deliveries of aggregate with fraction below 5 mm in order to minimize the storage level of fine aggregate. In available international technical literature such solutions in organization and management of the HMA production process have not been found (Ang et al. 1993; Grabowski et al. 2005).

Additionally, through adequate system of management the influence of capacity of AMP on the HMA production process, and therefore on the level of energy consumption, has been included in the analysis. The research output data, such as data presented by Bunz and Solbach (1981) differ from the research data. The capacity of the AMP has increased from ca 100–150 t/h to ca 240–300 t/h. There has been a technological progress related, among other, to the production of particular elements of the process, automation of almost each stage of the production, application of the materials minimizing the heat and energy loss. Nevertheless the theoretical assumptions remain unchanged, and the method of storing of the aggregate without roof remain unchanged in numerous production plants.

Analysis of German engineers such as Bunz and Solbach (1981) gave the possibility to compare the size of the parameters influencing and deciding on the level of the energy consumption in AMP, such as aggregate moisture, the size of HMA production. Nevertheless, presented by Bunz and Solbach (1981) linear dependence of heating oil consumption on the aggregate moisture without taking into account the size of the AMP production seem to be incomplete.

Measurement results of the aggregate moisture on slag heaps as well as the attempt of its reduction through the implementation of proper management of deliveries with equal increase of the capacity of HMA production permit to state that if each reduction of aggregate moisture by 1% causes reduction of fuel by ca 10% (Young 2008), then the decrease of aggregate moisture combined with increase of the AMP capacity will cause the decrease of heating oil consumption up to 50% (according to the authors of the paper from 1–7 l/per each produced ton of HMA).

## 5. Conclusions

The analyses of the test and measurement results of the energy consumption during the HMA production in 2007 and 2008 on two road construction contracts, where new solutions for the organization of HMA production have been applied, allow making conclusions.

In 2008, the planned coordination of the deliveries for each aggregate fraction for the HMA production, especially in the period of increased precipitation, allowed to reduce the level of moisture content of the aggregate located on the plant site, mainly of the 0/2 mm (0/5 mm) fraction, from 1% to 3% in comparison to the period of 2007, which additionally was characterized by unfavourable weather conditions.

The reduction in overall aggregate moisture content of about 1% decreases the real oil consumption by about 18%. This confirms the correctness of theoretical dependences that the reduction in moisture content of about 1% reduces the energy consumption by about 15%.

The preparation of the work that allows producing the HMA with high efficiency of AMP causes a reduction of fuel consumption from 1 l/t up to 7 l/t of the placed HMA, depending on the production size.

The organizational changes in the system of work and management of AMP may significantly influence the energy consumption in the HMA production process without additional financial costs. The applied changes regard the following elements of the HMA production:

- storing without roof the smallest possible amount of fine aggregate with fraction 0/2 and 2/5 mm the mostly exposed to moisture in case of unfavourable weather conditions;
- storing bigger amount of fine aggregate shortly before the start of the production and placing of HMA;
- placing HMA with maximum efficiency of AMP production.

Implementation of the above stated organizational solution enables the reduction of the heating oil up to 50%.

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