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ABILITIES OF ENERGY CONSUMPTION RATIONALIZATION IN INDIVIDUAL BOILER IN EDUCATIONAL BUILDINGS

The paper presents the results of investigations on abilities of energy consumption rationalization in individual boiler in educational buildings. Central heating is a system consisting of two main elements: heat source and central heating installation. The basic parameter in evaluation of central heating boilers is nominal η_n and useful η_u efficiency of heat production. The greater the efficiency of the central heating boiler, the less fuel should be used to produce a certain amount of heat. Differences in this case are considerable, which also influences energy consumption and costs of heating the building.

Introduction. While analysing the technical condition of central heating boilers operating in individual boiler-rooms their service life (OEK) should be taken into consideration. It is a factor that may have a considerable influence on heating fuel consumption. The aforementioned value should be examined in two ways. Firstly, the influence of the boiler age on its efficiency is obvious, as it is connected with the technical ageing of the applied solutions. Secondly, the service life of the heat source when its technical service is neglected also has a negative influence on its efficiency.

The basic parameter in evaluation of central heating boilers is nominal efficiency η_n provided by a producer and useful efficiency η_u characterising the actual efficiency of its performance. Apart from direct measuring method of evaluating efficiency, it may also be measured using the indirect method, knowing the total value of the heat losses during combustion [2].

The aforementioned heat losses are: a carry-over loss, deficient combustion loss, incomplete combustion loss, loss to the environment, blowdown loss, and banking loss. Only the first four are considered in practice. The average values of the sum of the heat losses amount to 19–38% for stoker-fired central heating boilers with manual loading and for gas fired boilers up to 15–28% [1].

Determining the value of useful efficiency η_u of central heating boilers it is an easy solution to calculate η_u of a given boiler on the basis of the obtained information and data concerning the technical parameters of the boiler and conditions of its exploitation. This method may be used especially when analysing the possibilities of the rationalisation of heating buildings. The existing results of the research on the useful efficiency of central heating boilers of different types [1] (table 1) are helpful in this case.

Table I

Useful efficiency η_u of central heating boilers of different types [1]

Central heating boilers	η_u, %
Boilers using hard coal and coke	50 - 55
Older construction boilers using fuel oil	63 - 65
New construction boilers using fuel oil	90
Older construction boilers using natural gas	65 - 70
Boilers using natural gas	74 - 78
New boilers using natural gas for central heating and heat water	91 - 93
New condensational boilers using natural gas	98

Discussing the efficiency of individual heat sources one should mention its changes in relation to boiler rating fig.1. Keeping the boiler rating on one, relatively stable, level is impossible, that is why the optimal rating range for the useful efficiency from 50 to 100% of the boiler power rating was introduced.

In the works on the subject there were also deliberations on the compatibility of the used fuel with the recommendations of central heating boilers' producers as well as on the quality of fuel and the possible influence on its consumption. This problem is significant in our country most of all for solid fuel boilers (coal and coke). Often it is claimed [1] that the fuel of worse quality causes lower power rating and increases the fuel consumption. However it may turn out that the heating costs will still be lower than when better fuel is used.

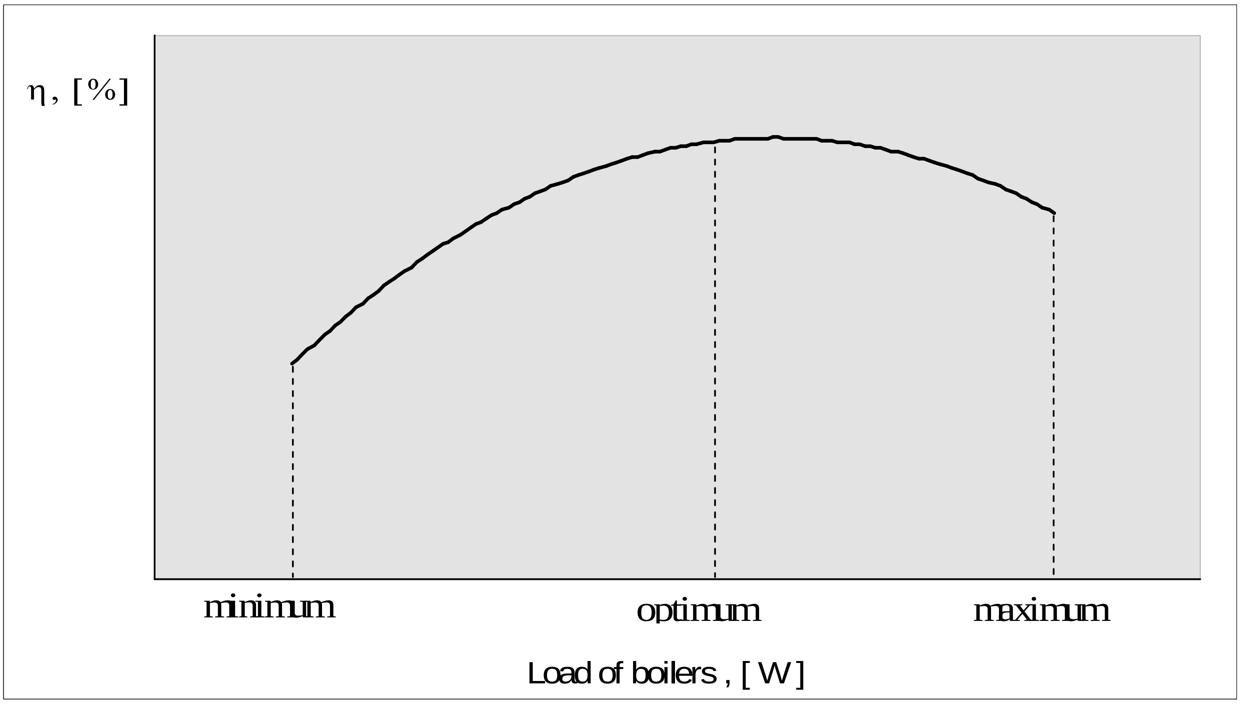

Fig. 1. Efficiency η of central heating boiler as a function of boiler rating [2]

Results of research. In the analysed complex of school buildings consisting of 50 buildings in Częstochowa, 27 schools are heated from their own sources. Altogether LK= 53 central heating boilers were installed in the school boiler-rooms. In this number Lkp = 48 working boilers, Lkr = 4 stand-by boilers and Lku = 1 boiler out of order were identified. 20 boiler-rooms had coal-fired or coke-fired central heating boilers and 7 used natural gas. The average period of boiler exploitation amounted to $OEK_{śr}$ = 9.5 years (table 2), and it was typical that about 70% of central heating boilers had been used from about 1.5 to 17 years. Additionally 60% of the aforementioned equipment has been used for less than 9 years. Additional information is presented in table 2.

The influence of the exploitation period OEK of a boiler on the fuel consumption was evaluated indirectly. That is why the influence of the aforementioned exploitation period on the quantity of used theoretical standard fuel (PU in short) for producing 1 GJ of heat Q used for the period of central heating of flats was examined. The aforementioned dependence was presented in fig.2. As a result of the analysis it was stated that the amount of fuel necessary for generating a fuel unit is in about 60% dependent on the exploitation period of central heating boiler. However, the greatest changes PU/Q have been observed for the first 10 years of boiler operation. Later on these changes have been reduced twofold, to disappear almost completely for over 20-year exploitation period.

The statistic analysis was also made for the selected parameters of the central heating boilers working in school boiler-rooms.

The following quantities were considered: the average nominal central heating boiler efficiency η_n, the average estimated useful efficiency of the boiler η_u, the average index of applying the recommended fuel $WPz_{śr}$ in working coal or coke-fired boilers, the average index of using boiler power $WMK_{śr}$.

Table II

Basic measuring tools of statistic description for the selected quantities characterising central heating boilers in school boiler-rooms

Quantity	Selected tools of statistic description					
	Mean value x_{av}	Empirical range of variability O (x)	Standard deviation s (x)	Typicality boundaries x_{typ}	Coefficient of variation Vk (x)	Stress ratio Ask (x)
OEK ,years	9,5	26,00	—	1,50 - 17,00	81,35	0,97
ηn , %	78,93	21,00	6,28	72,65 - 85,20	7,95	0,78
ηu , %	65,33	27,00	8,23	57,10 - 73,57	12,60	0,40
WPz , -	0,68	—	—	—	—	—
WMK , -	0,81	1,17	0,22	0,59 - 1,03	27,36	—

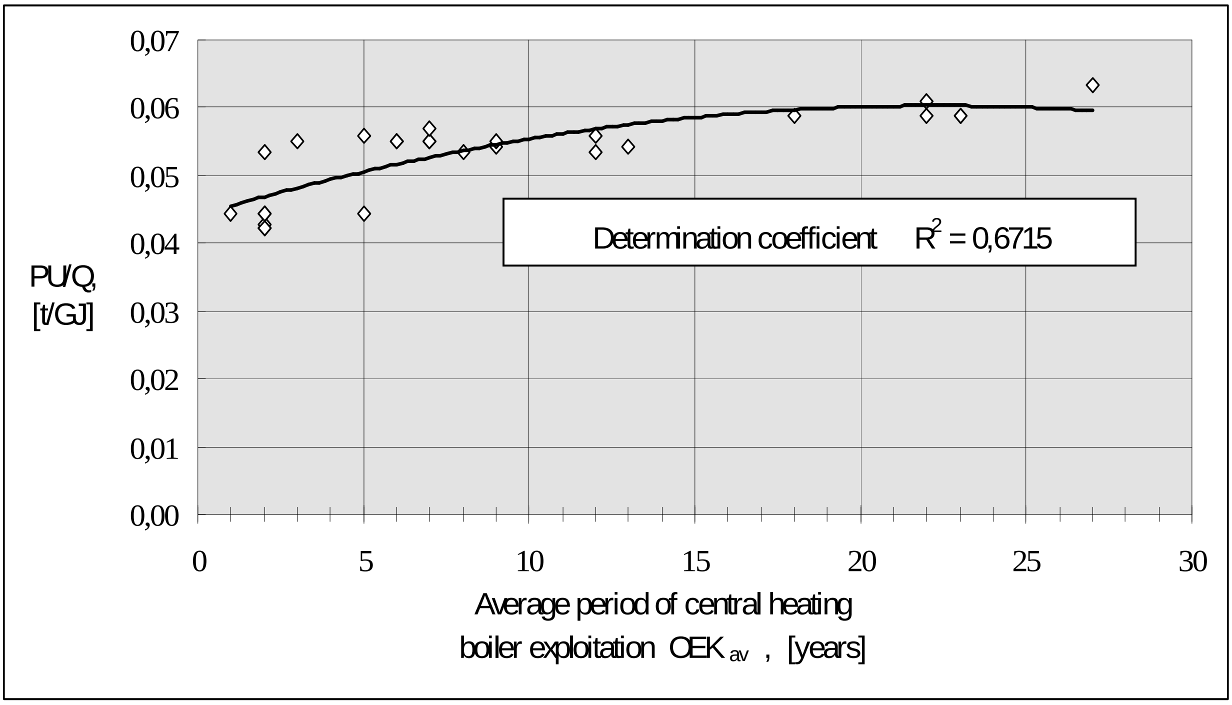

Fig. 2. Fuel consumption required to produce 1 GJ of heat in school boiler-rooms depending on the average exploitation period OEK $_{av}$ of a boiler

Analysing the data included in table 1, it was stated that only 25 % of boilers show values η_u greater than 70 % and these are natural gas-fired boilers. To evaluate the influence of the discussed quantities on the heat consumption Q to heat school buildings an index PU/Q was used. Using its values and the values of parameters characterising heat sources diagrams of dependence were drawn and presented in fig. 3, 4, 5 and 6.

Taking into consideration the presented diagrams, in the case of $WPz_{śr}$ index statistically negligible influence on the values of PU/Q index was found. A certain statistically insignificant influence on the values PU/Q is also exerted by the adjustment of boiler power to power demand q of the heated buildings (fig.6). Statistic lack of the influence of $WPz_{śr}$ and $WMK_{śr}$ on the values of PU/Q index shows the possibility of improper exploitation of central heating boilers. While the high values of linear correlation coefficients r for the dependence between PU/Q and $\eta_{n\ śr}$ and $\eta_{u\ śr}$ as well as their statistic significance proven experimentally by Student's t-test show a great power of this dependence.

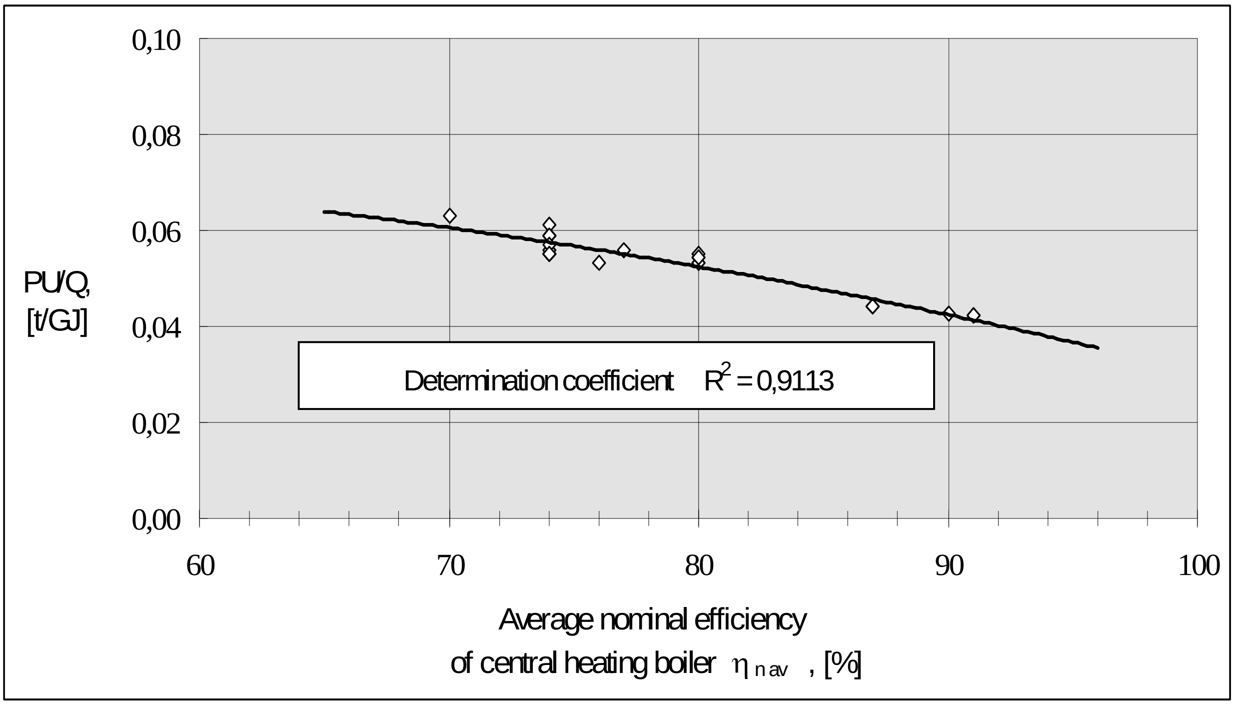

Fig. 3. Fuel consumption to produce 1 GJ of heat depending on nominal central heating boiler efficiency η_n

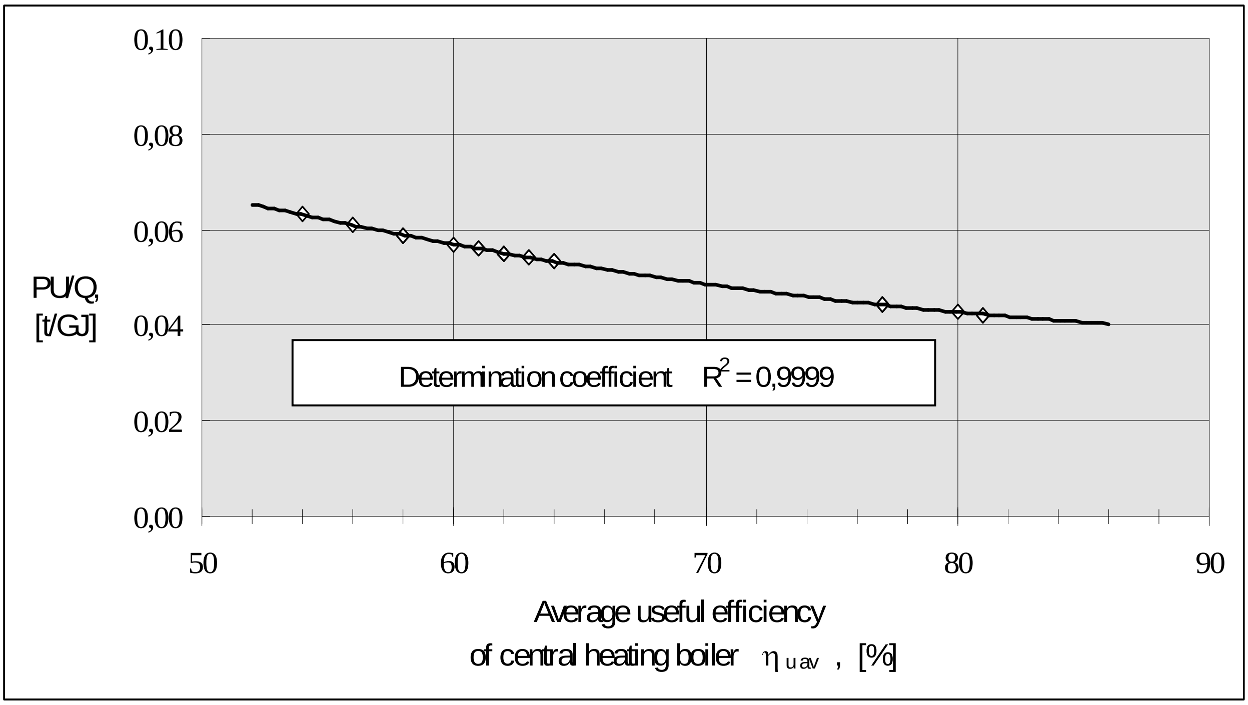

Fig. 4. Fuel consumption to produce 1 GJ of heat in school boiler-rooms depending on estimated η_u *of working boiler*

The mean values of index of using recommended by boiler producers types and brands of fuel ($WPz_{śr}$) were analysed. It has been researched to what extent the service staff of school boiler-rooms uses the aforementioned fuels.

The results were presented in the form of a diagram in fig. 5. It should be stressed that deviations from the requirements in this respect concern only boiler-rooms using coal or coke. It has been revealed that coke was used, exclusively or mainly, instead of the recommended hard coal. Frequent cases of adding to the recommended coke some amount of hard coal were much less significant. In gas boiler-rooms these anomalies did not occur.

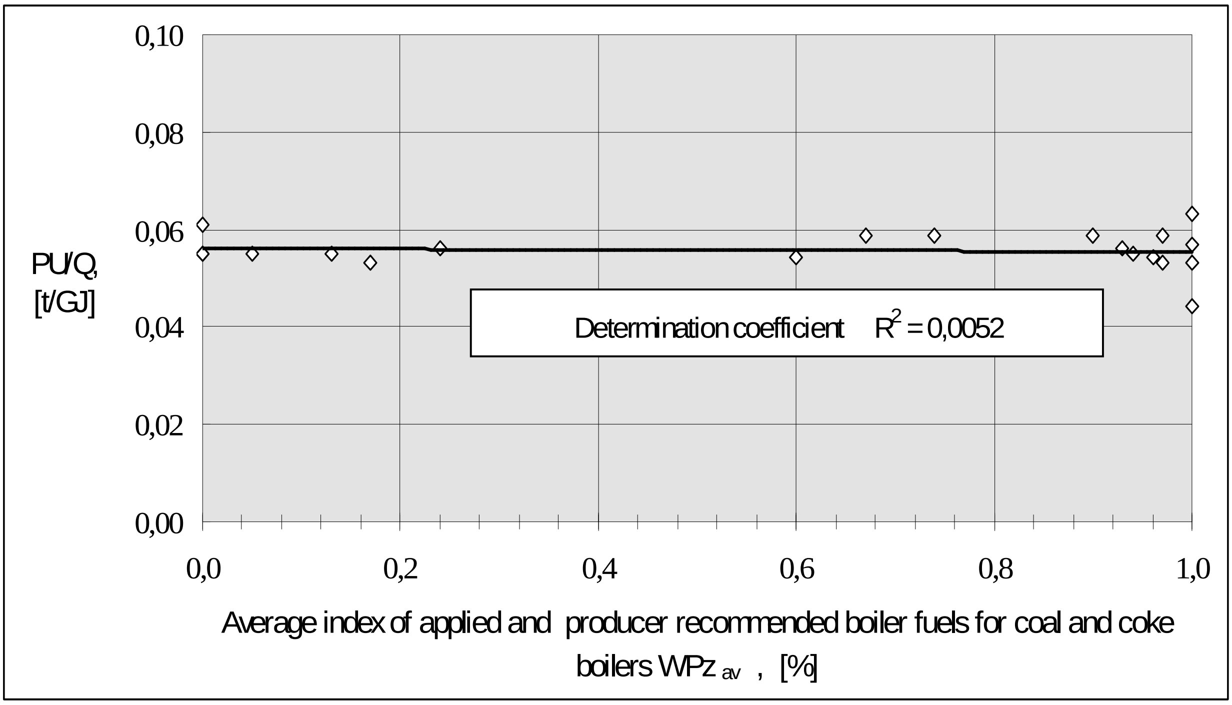

Fig. 5. Fuel consumption required to produce 1 GJ of heat in school boiler-rooms depending on the index of using recommended fuel WPz_{av}

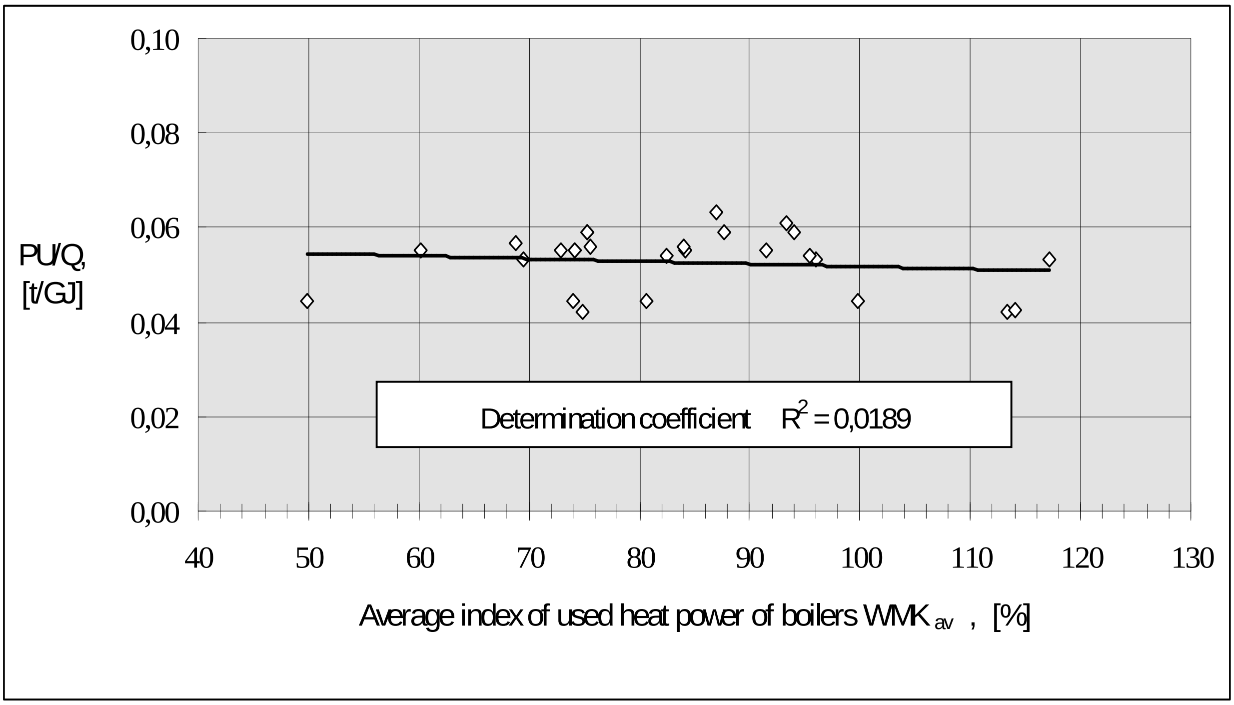

Fig. 6. Fuel consumption required to produce 1 GJ of heat in school boiler-rooms depending on the index of using the power of working boiler WMK_{av}

Discussion and summary.

– Among 27 school buildings supplied with heat from their own boiler-rooms only 7 buildings (26%) had boiler-rooms equipped with rather modern central heating boilers using natural gas. The average efficiency of these boilers amounted to 89% and 79% for the nominal η_n and useful η_u efficiency. In other buildings the boilers using hard coal and coke of mean values of nominal efficiency $\eta_{n\,śr}$ = 73% and useful efficiency $\eta_{u\,śr}$ = 60% were the heat sources. About 40% of working equipment of this type is over 9 years old. The presented situation proves that there is unfulfilled potential of modernising the individual heat sources.

– Equipping the already working central heating boilers using natural gas with more advanced automatics will increase the efficiency of heat source adjustment and will lower the heat consumption by 5–15%, thanks to using periodicity and operation specificity of school buildings. The aforementioned activities should be accompanied by other modernisation projects.

– Taking into consideration the maximum efficiency of central heating boilers with the specified load appropriate, low-budget organisational activities aimed at creating favourable conditions should be undertaken. These activities are as follows: drawing up a schedule of operation of CH boiler group, drawing up a user manual and the current central heating boilers control of the observance of the instructions. They will enable the reduction of seasonal fuel consumption by 3 – 8%. For example, a small amount of soot and ashes from 1 to 2 mm may cause the power decrease of a hard coal boiler even by 30%. As visits at schools showed there are unfulfilled possibilities in this respect

– The conducted analyses did not prove statistically significant relationship between indexes WPz and WMK and an amount of the theoretical standard fuel necessary to produce 1 GJ of heat. It proves indirectly the lack of gross deviations from the aforementioned rules concerning the choice of central heating boilers. Frequent cases of using a different fuel than recommended by the producer in school-rooms were observed, however without a significant influence on heat production efficiency.

– The costs of producing 1 GJ of heat for heating school buildings get reduced in the buildings with their own heat sources together with the seasonal increase of heat consumption. This dependency does not exist in the case of schools supplied with heat by Heating Enterprise, which uses up the created economic effect, and does not take this fact into consideration and lower central heating charges.

1. Górzyński J.: Energy Audit of Industrial Buildings. Fundacja Poszanowania Energii. Warszawa 1995 (In Polish). 2. Lis P.: Identifications of Modernising Reserves in Individual Sources of Heat in School Buildings. Fuel and Energy Management¹ Ch. LI (584): 2003 number 2, pp. 9-13 (In Polish)

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ON THE PROBLEM OF SAFETY EVALUATION IN DESIGN OF STEEL MEMBERS FOR ACCIDENTAL FIRE SITUATION

Failure probability can be applied as a basic safety measure in design of structural member under fire conditions. To reliable assess this value interacted influences of many factors should be taken into account. Some suggestions in this field are given in this paper.

Introduction. The reliable safety measure in design of steel members for fire situation is probability of failure $p_f = P(F)$. The failure in this case does not have to deal with complete decay of the opportunity to carry all external loads (including thermally generated internal forces and moments caused by fire)