FUGITIVE EMISSIONS FROM FUELS:

NFR 1B1b SOLID FUEL TRANSFORMATION

Miloslav Modlík

(CHMI)

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Czech Hydrometeorological Institute

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Solid fuel transformation (NFR 1B1b)

In the period 1990–2015, six coking plants were in operation in the Czech Republic, of which three were operated within steelworks. As a consequence of reconstruction of the national economy and the introduction of emission limits, in the 1990s these works underwent modernization whereas others decreased or stopped their production. In 1997 production was stopped at the ČSA coking plant, and one year later it also ceased at the coking plant of the Vítkovické železárny steelworks. Coke production decreased further in 2010 when production ended at the Jan Šverma coking plant. Currently there are three operational coke plants with nine coke oven batteries (Table 1).

TABLE 1 SUMMARY OF COKING BATTERIES AND THEIR PARAMETERS IN THE YEAR 2015

Coke oven plants	Battery	Count of chambers	Capacity	Type of charging
ArcelorMittal Ostrava a.s.-závod 10-Koksovna	KB1	72	378000 t/year	stamp charging system
ArcelorMittal Ostrava a.s.-závod 10-Koksovna	KB2	72	378000 t/year	stamp charging system
ArcelorMittal Ostrava a.s.-závod 10-Koksovna	VKB 11	60	775000 t/year	top charging systems
OKK Koksovny, a.s. - Koksovna Svoboda	KB 7	50	204000 t/year	stamp charging system
OKK Koksovny, a.s. - Koksovna Svoboda	KB 8	54	214000 t/year	stamp charging system
OKK Koksovny, a.s. - Koksovna Svoboda	KB 9	50	204000 t/year	stamp charging system
OKK Koksovny, a.s. - Koksovna Svoboda	KB 10	56	218000 t/year	stamp charging system
TŘINECKÉ ŽELEZÁRNY, a.s. - Koksochemická výroba	KB 11	72	371400 t/year	stamp charging system
TŘINECKÉ ŽELEZÁRNY, a.s. - Koksochemická výroba	KB 12	72	350000 t/year	stamp charging system

Coke production in the years 2000–2008 was around 3.3 million tonnes. After 2008 it decreased to 2.2 million tonnes due to the economic crisis and limitations of the operation of some coking batteries (Figure 1).

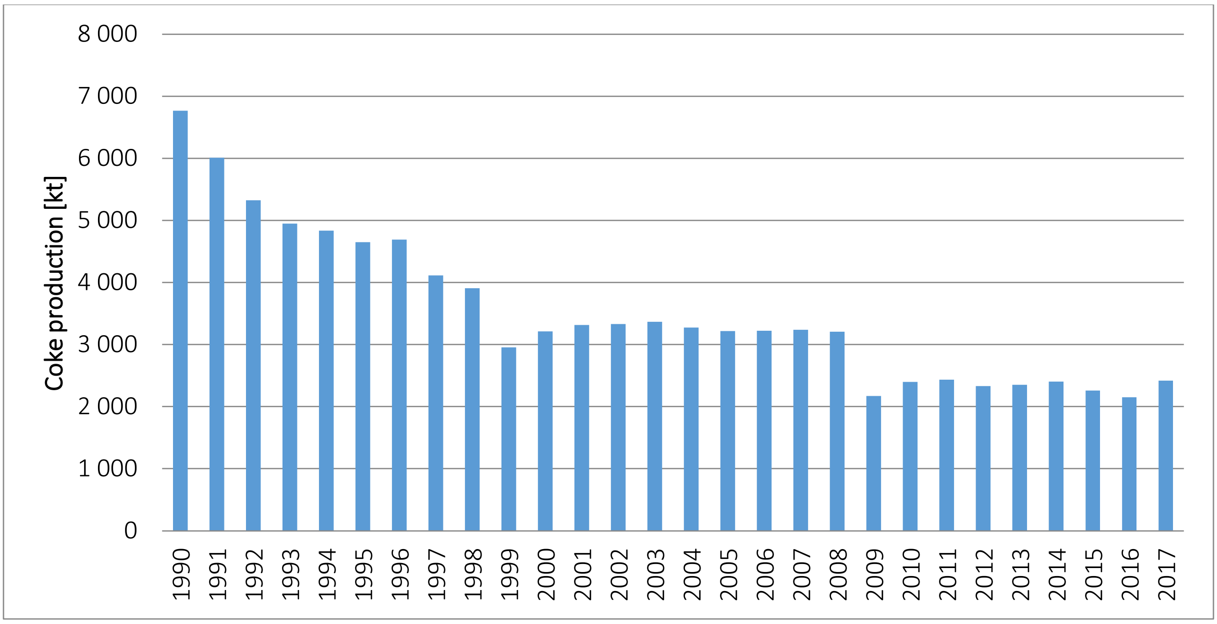

FIGURE 1 COKE PRODUCTION IN 1990-2017

From the perspective of emissions inventorying, the process of coke production is divided into six sectors (Table 2). These are individually monitored sources listed in Annex 2 to the Law. Emissions from these sources are ascertained by measurements. One exception is the process of coke production, during which fugitive emissions escape due to leakages of coking batteries.

TABLE 2 MAPPING OF NFR 1A1c AND 1B1b SOURCE CATEGORIES TO ANNEX 2 SOURCE CATEGORIES

NFR	Coke production - coking batteries	TSP	SO_X	NO_X	PAH	H_2S	CO	VOC	NH_3	HCN	C_6H_6
1A1c	3.5.1. Coking battery heater	M	M	M			M	M			
1B1b	3.5.2. Coal charge preparation	M						M			
1B1b	3.5.3. Coking	C	C	C	C	C	C	C	C	C	C
1B1b	3.5.4. Coke extrusion	M			M						
1B1b	3.5.5. Coke classification	M									
1B1b	3.5.6. Coke cooling	M									

M – measurement
C – calculation

Individual coking plants differ from each other and do not necessarily include all sources. The preparation of coal charge usually entails storage of coal, grinding of coal, mixing of coal or the processing of tar. For the heating of coking batteries, technical grade coking gas, blast furnace gas or mixed gas is usually used. Besides emissions from leaking coking batteries, the coking process also produces emissions from the extraction, transport and cleaning of crude coking gas and from the processing of chemical products.

Emissions from the coke production process are being ascertained according to a unified methodology of quantifying emissions from coking plants[1]. The methodology is based on measuring emissions and visual observation of emissions being released. Measurements are made for one coking chamber of each coking battery during entire coking cycles. The measurements are repeated once every five years. Visual assessment is carried out at least 250 times a year. If a smoke plume smaller than 2 m is detected, the emissions are assumed to be 20-fold higher than measured values of emission flux. If a smoke plume larger than 2 m is observed, the emissions are assumed to be 200-fold the values of the emission flux from a tight source.

The annual amount of emissions from the coking process can be calculated using the following formula:

$$ET(ko)_i = \sum EF(kd)_i \cdot A \cdot 10^{-6}$$

- $ET(ko)_i$ – annual emission rate of pollutant „i“ from the coking of coal charge in one coking battery [t.year^{1}]
- $EF(kd)_i$ emission factor of pollutant „i“ for a sub-source during the technological process of coking over the duration of one cycle in one coking chamber [g.cycle^{-1}]
- A – overall number of cycles per year for one coking battery [cycle.year^{-1}]

[1] Surý, A., Čech, L., 2011. Jednotný metodický postup vyčíslování emisí z koksoven České republiky. HUTNÍ PROJEKT Frýdek-Místek.

The following applies to coking batteries with stamp charging operation:

$$EF(kd)_i = EF_i \cdot k_{1-5} \cdot \left(k_0 \cdot \frac{Pt_{1-5}}{Pp_{1-5}} + k_{20} \cdot \frac{Pn_{1-5}}{Pp_{1-5}} + k_{200} \cdot \frac{Ps_{1-5}}{Pp_{1-5}}\right)$$

The following applies to coking batteries with top charging operation:

$$EF(kd)_i = EF_i \cdot k_{1-6} \cdot \left(k_0 \cdot \frac{Pt_{1-6}}{Pp_{1-6}} + k_{20} \cdot \frac{Pn_{1-6}}{Pp_{1-6}} + k_{200} \cdot \frac{Ps_{1-6}}{Pp_{1-6}}\right)$$

- EF_i – emission factor of pollutant „i“ over the duration of one cycle for one coking chamber; it is ascertained by measuring leakages from furnace doors [$g.cycle^{-1}$]
- Pp – number of units in operation; arithmetic mean of the number of sub-sources of emissions in operation per year calculated based on all observations made
- Pt – number of tight units; arithmetic mean of the number of tight sub-sources per year calculated based on all observations made; Pt = Pp – Pn – Ps
- Pn – number of leaking units; arithmetic mean of the number of leaking sub-sources per year calculated based on all observations made
- Ps – number of unadjusted units; arithmetic mean of the number of unadjusted sub-sources per year calculated based on all observations made
- k_0, k_{20}, k_{200} – correction coefficients for source tightness (Table 5)
- k_{1-5} – contribution coefficients for coking batteries with stamp charging operation
- k_{1-6} – contribution coefficients for coking batteries with stamp charging operation

Emission rates from sub-units are quantified by estimation based on the proportionality to measured values of emissions from furnace doors of the corresponding coking battery (Table 3 and Table 4).

TABLE CHYBA! V DOKUMENTU NENÍ ŽÁDNÝ TEXT V ZADANÉM STYLU. PROPORTIONALITY BETWEEN SUB-SOURCES DURING THE COKING PROCESS – STAMP CHARGING OPERATION

Source	Proportional contribution [%]	k_{1-5}
doors on the machine side	35	0.35
doors on the coke side	35	0.35
connecting (suction) openings	15	0.15
Shafts	5	0.05
other emission sources	10	0.1

TABLE 4 PROPORTIONALITY BETWEEN SUB-SOURCES INVOLVED IN THE COKING PROCESS – WITH TOP CHARGING OPERATION

Source	Proportional contribution [%]	k_{1-6}
doors on the machine side	25	0.25
doors on the coke side	25	0.25
comparison doors	10	0.1
Shafts	10	0.1
filling openings	20	0.2
other emission sources	10	0.1

TABLE 5 CORRECTION FOR OPERATIONAL STATE ASSESSED VISUALLY FOR THE DETERMINED PERCENTAGE OF TIGHT, LEAKING AND UNADJUSTED SOURCES

$k_0 = 1$	tight sources (no smoke plume detected by visual observation)
$k_{20} = 20$	leaking sources (smoke plume smaller than 2 m detected by visual observation)
$k_{200} = 200$	unadjusted sources (smoke plume larger than 2 m detected by visual observation)

Until 2008, in accordance with the legislature current at the time (Decree 356/2002 Coll.), PAH emissions were measured as the sum of ten congeners:

- fluoranthene
- pyrene
- benzo(a)anthracene
- chrysene
- benzo(b)fluoranthene
- benzo(k)fluoranthene
- benzo(a)pyrene
- dibenzo(a,h)anthracene
- benzo(g,h,i)perylene
- indeno(1,2,3-cd)pyrene

Since 2009 PAH emissions had been measured as the sum of four congeners: benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene. For the purpose of estimating emissions of individual congeners, their contributions to the total sum of PAH were obtained by analysing protocols from one-off measurements (Table 6).

TABLE 6 CONTRIBUTIONS OF INDIVIDUAL CONGENERS TO THE TOTAL SUM OF PAH

Process	benzo(a)pyrene		benzo(b)fluorantene		benzo(k)fluorantene		indeno(1,2,3-cd)pyrene	
	% 10PAH	% 4PAH	% 10PAH	% 4PAH	% 10PAH	% 4PAH	% 10PAH	% 4PAH
Coking	5	25	7	41	4	20	2	14
Coke extrusion	5	23	7	42	4	21	2	14