Greenhouse Gas from Industry Process and Product Use in Foundry Industry

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Abstract: Both CO2 and non-CO2 Greenhouse Gas (GHG) may be found in foundry Industry Process and Product Use (IPPU). CO2 may be emitted by using organic additives in sand. SF6 was popular in Mg-alloy die-casting, which may cause an extremely high CO2-eq emission. It was probable to find a trace amount of CH4 in leaking of natural gas use; HFCs and PFCs in air conditioning, refrigeration and waste heat recovery and utilization equipment or as substitutes for SF6. These emissions may not always be negligible, unless fluoride GHGs controlled below 0.198-32.4 g/t-casting. IPPU GHGs exist in both foundry equipment and general equipment and should be accounted as Scope 1 or 3. Foundries need more attention on IPPU GHGs.

Keywords: greenhouse gas (GHG); carbon emission; industry process and product use (IPPU); foundry

1 Introduction

China has submitted its CO_2 goals and every Chinese corporation and industry is preparing its own. Energy is the priority concern in carbon issues but not the only one. The climate crisis is attributed to all types of Greenhouse Gases (GHGs) including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). Non-CO_2 GHGs have high Global Warming Potential (GWP) and may cause high equivalent CO_2 emission (CO_2-eq). These gases are usually found in Industry Process and Product Use (IPPU), where CO_2 without fuel or energy relation also exists. Foundry is a relatively small industry and just started working on carbon issues lately. Most foundry corporations had begun accounting for CO_2 emissions from their energy consumption including direct fossil fuel using as Scope 1 and electricity using as Scope 2. However, IPPU emissions and Non-CO_2 GHGs were merely considered by the foundry industry, also with rare research attracted. The existence, significance and necessity for accounting of IPPU GHGs in the foundry industry remain in chaos.

2 Possible IPPU GHGs sources in foundry

2.1 CO_2

The carbon lost in iron and steel during casting is left as CO_2. Meanwhile, organic materials are popular in mold nowadays, which could be converted into CO_2 in every process with high temperature: pouring, warmth maintaining and sand reclamation. These CO_2 emissions were concluded in Table 1, and should be accounted as IPPU in Scope 1.

Table 1. CO2 in foundry IPPU

	Source	Main emission process	Emission poteitial* ($kgCO_2/kg$)
Metal	Carbon in iron/steel	Melting	-
Mold-green sand	Coal	Pouring, warmth maintaining and sand reclamation	1.94
	Starch/dextrin ($C_6H_{10}O_5$)		1.63
Mold-resin sand	Furan ($C_8H_{10}O_3N_2$)		1.93
	Phenolic aldehyde (C_7H_6O)		2.91
Lost foam casting	Expanded polystyrene (EPS, C_8H_8)	Pouring	3.38

* Calculated by molecular formula

2.2 Non-CO2 GHGs

SF_6 was widely used for magnesium melting protection and 90%-100% SF_6 utilized would be emitted as GHG burden [1]. Though the magnesium industry has been trying to eliminate SF_6 over the past decade, the usage is still common recently [2], while several substitutes for SF_6 e.g. HFC-134a (HFCs) or CF_4 (PFCs) are also GHG. For other GHGs, CH_4 leaking was possible in furnaces using natural gas. In cupolas or vehicles (cars, trucks or fork lifters), NO_x was controlled as an air pollutant in exhaust gas, where the existence of N_2O needs verifying. Refrigerants GHGs may be found in waste heat recovery systems, which is a raising interest for foundries, e.g. organic Rankine cycles [3]. All these non-CO_2, as shown in Table 2, were in IPPU and should be accounted as Scope 1 or 3 (depending on proprietorship and accounting boundary).

Table 2. Non-CO2 GHGs in foundry

	GWP [4]	Existence	Possible source	
			Foundry equipment	General equipment
CH_4	27.9	Trace	Natural gas leak	
N_2O	273	Possible trace	Cupola	Vehicle

HFCs	1530 (HFC-134a), 14600 (HFC-23), 771 (HFC-32), 3740 (HFC-125), 5810 (HFC-143a)	Trace	Cover gas in Mg-alloy die-casting	Air conditioner and refrigeration, organic heat recovery system, electric insulation
PFCs	7380 (CF_4), 12400 (C_2F_6)	Trace		Electric insulation
SF_6	25200	Some or trace		
NF_3	17400	Not found	-	-

3 Significance evaluation

In accounting, the ignoring of IPPU GHGs could only be acceptable when the CO_2-eq was low, e.g. 1% of the total emission. The carbon footprint of casting was reported as 1.2-2.8 tCO_2/t-casting [5] or 0.87 tCO_2/t-casting, of which more than 50% is attributed to melting and 30% is embedded in pig iron [6]. Thus, in common foundry GHGs accounting only including Scope 1&2, choosing 0.5-2.5 tCO_2/t-casting may be reasonable as a reference. Assigning 1% CO_2-eq or below to be negligible emission amount, tolerant limitations for each IPPU GHGs were calculated in Figure 1.

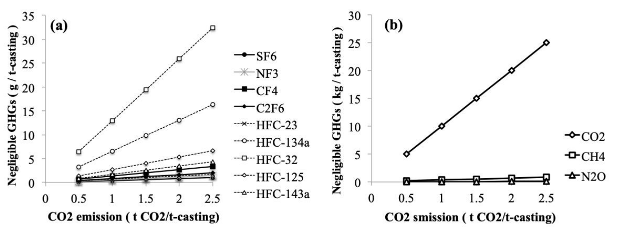

Figure 1 The tolerant limitation (1% CO_2-aq of total CO_2 emission) for each IPPU GHGs was calculated.

With high GWP, the tolerant limitation for fluoride GHGs was extremely low, with a range of 0.198-32.4 g/t-casting. For an Mg-alloy die-casting foundry emitted 1 tCO2/t-casting with 10,000 t-casting/year, SF_6 should be controlled under 3.97 kg/year (i.e. 10.9 g/day) to avoid a significant raise in CO_2-eq accounting. Using data in Table 1, assuming 1-5 t sand/t-casting and 1%-2% organic materials added in sand with 10% complete combustion into CO_2, emission was estimated to be 1.9-29.1 kg CO_2/t-casting. Compared with Fig.1(b), this will not always be negligible. Both IPPU CO_2 and non-CO_2 GHGs could be significant for foundries under certain conditions.

4 Conclusion and outlook

IPPU GHGs can be found in the foundry industry. IPPU CO_2 is emitted from organic materials including coal and starch/dextrin powder, furan or phenolic aldehyde resin and EPS. Among non-CO_2 GHGs, SF_6 is typical in Mg-alloy die-casting foundries and may lead to an inconceivable CO_2-eq accounting; CH_4 and N_2O may be found in furnaces; HFCs and PFCs may be used as substitutes for SF_6 or refrigerants in general equipment. All these should be accounted as Scope 1 or 3, otherwise controlled below 0.198-32.4 g/t-casting for fluoride GHGs to neglect, which might be hard, especially for Mg-alloy die-casting foundries.

As an energy-intensive industry, foundries were used to omit or ignore IPPU GHGs as an assumption with no question. The results of this study attempted to show the risk of such practices under stringent carbon and climate policy in the future. More attention and much more study will be needed on IPPU GHGs for the foundry industry and corporations.

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