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Modeling Pollutants Emissions in Iron and Steel Industry (Case Study: Iranian Ghadir Iron & Steel Company)

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Keywords

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Abstract

Process modeling is used in order to analyze the distribution of contaminants in the environment or the destruction of the environment. In this regard, one of the most suitable models in line with the used process in predicting the effects and the environmental risk assessment of iron and steel industries, is the chemical screening tool for exposures and environmental releases (ChemSTEER) as a screening tool relative to the human contact and distribution of contaminants corresponding to the resources of the host environment. ChemSTEER is a computer-based software program developed by the US Environmental Protection Agency (EPA), Office of Pollution Prevention and Toxics (OPPT), that can be used to conduct a screening-level workplace exposure and release assessment. This article introduces the brevity of this model and its application in the emission of the contaminants. According to the results, it can be concluded that working conditions in the mentioned factory in terms of risky contacts due to processing procedures and sponge iron production method, has an acceptable condition in a long term operation range of the industry.

1. Introduction

Industrial pollution has become a major problem in countries within rapid industrialization. Use of older processing technologies, poor pollution control systems, and inadequate attention to the environmental impacts cause deterioration of environmental quality [1].

The steel industry is one of the largest industries in the country and due to its application, and steel key role in various parts, the steel industry is of particular economic importance. These days, the focus and human society concern is shifted to protecting the environment. Also, complaince with the environmental standards in order to sustain human life on the planet is of serious requirements. Obviously, in such circumstances, one of the main concerns of the steel industry such as other industries, should be its impact on the environment and its role in the process of sustainable development. The modeling of pollutants distribution by evaluating the effect of various parameters on production and emissions of pollution helps considering some measures to control the optimization of contamination [2].

2. Material and Method

2.1. Definition of the Case Study Unit

Iranian Ghadir Iron and Steel Co. was found in 2006 in order to fulfill the needs of the sponge iron for the iron and steel company of Iran, melting and casting units of Yazd province and other steel producers of the country. This company with a distance of 25 kilometers from the city of Ardakan, Yazd Province, is located beside the Chadormalu Pelletizing Complex and Arfa Iron and Steel Co. in an area of 700 hectors having annual capacity of 800,000 tons. The project employment rate is over 205 people directly and more than 1,500 people indirectly. Feed of the company is 1/200/000 tons of iron ore annually, which is provided by the Ardakan pelletizing plant. Iran is the second largest producer of sponge iron after India by direct reduction method. With the launch of this factory since 1389, the country's annual production capacity has been increased to 800.000 tones. After India and Iran, Venezuela and Mexico are ranked the third and fourth countries in producing sponge iron.

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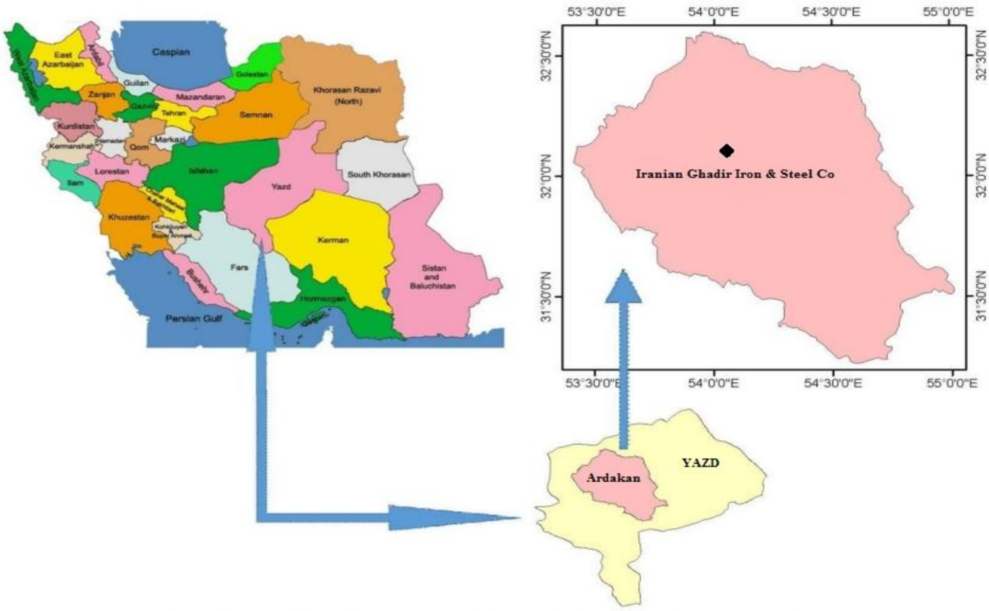

Figure 1. Location of the Iranian Ghadir Iron & Steel Company

2.2. An Intrduction to ChemSTEER Model

In 2004, this model has been prodused by Office of pollution prevention & toxics (EPA) of the U.S.A [3]. It is worth noting that in general, the developed models by the mentioned organization are divided to three models: Screening level models, second level models (Simulation based models) and advanced dispersion models. The present model is considered the first level models which is actually a model for estimating chemical materials in terms of their emissions in in the workplace (workshop) and also the level of human exposure (skin and respiratory) with chemicals in the workplace to the workforce employing in an industrial unit [4]. More precisely, in ChemSTEER model the amount of emissions and various chemicals contact in a factory environment or any other unit which has a kind of contact with that chemical substance are estimated regarding work force and the acceptor environment(Figure 2). Particularly, this model shows its functionality better in situations where there is not a lot of monitoring dataof the processes’ posittions available [5].

At the moment, this model is widely used internationally in the following cases:

- Estimating human exposure and distribution of new chemical pollutants under assessment for the preparation of the environmental database for the future use in an operating industrial-manufacturing unit.
- Presentation of future programs in order to benefit environmental sustainable industrial plants
- Completing the lack of data in an evaluation process of human contact with chemicals in the workplace.
- Using as a green or eco-friendly design tool for benefing engineer designers of the industrial units in the initial phase of engineering designs.

It should be noted that the initial estimates based on the mentioned model, are mostly conservative and in fact, the amount of emissions and human contacts obtained from these models, are mainly more than the actual values that occur during the process.

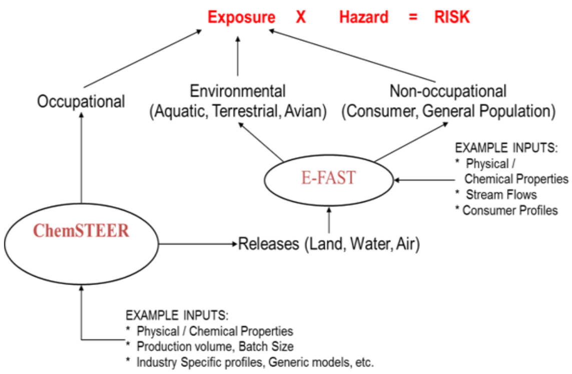

Figure 2. Exposure Information Flow in New Chemicals Risk Screening

2.3. Types of Estimates in the ChemSTEER Model

Following is illustrated the list of capabilities of estimates and performance assessment types which are used based on the sensitivity and the necessity in ChemSTEER model.

- Low Release and human Exposure exemption (High sensetivity) LOREX
- Low Volume Exemption (LVE)
- Pre-manufacture notice (Moderate sensetivity)
- Enforcement (High sensetivity)
- Preliminary risk management assessment (Low sensetivity)
- Detailed preliminary risk management assessment (High sensetivity)

2.4. Model Input Parameters and Values

The EPA/OPPT Direct 2-Hand Dermal Contact with Solids Model values for each of the input parameters are summarized in Table 1-2 [6-7].

Table 1. Model Input Parameters and Values

Parameters	Description	Equation	Units
Dexp	Dermal potential dose rate	S × Qu × Yderm × FT	mg/day
NW	Total number of workers exposed	NWexp × NS	workers
LADD	Lifetime average daily dose	(Dexp × ED × EY)/(BW × ATc × 365 days/yr)	mg/kg-day
ADD	Average daily dose	(Dexp × ED × EY)/(BW × AT × 365 days/yr)	mg/kg-day
APDR	Acute potential dose rate	Dexp/BW	mg/kg-day

Table 2. Input Parameters and Values for the EPA/OPPT Direct 2-Hand Dermal Contact with Solids Mode

Parameter	Description	Value(s)	Units
S × Qu	Total amount of solids on skin	7,500	mg/event
Yderm	Weight fraction of chemical in liquid (0 ≤ Yderm ≤ 1)	1	Dimensionless
FT	Frequency of events (0 ≤ FT (integer)	1	events/worker-day
Nwexp	Number of workers exposed while performing the activity	1	workers/site
NS	Number or sites	1	site(s)
ED	Days exposed per year (0 ≤ ED (integer) ≤ 365)	250	days/site-yr
EY	Years of occupational exposure (0 ≤ EY)	40	Years
BW	Body weight (0 ≤ ATc)	70	Kg
Atc	Averaging time over a lifetime (chronic) (0 ≤ ATc)	70	Years
AT	Averaging time (EY ≤ AT ≤ ATc)	EY	Years

3. Results and Discussions

In modeling related to the Iranian Ghadir Iron and Steel Co., direct reduction furnace (which uses a conventional method and high-efficiency direct reduction of iron oxide to sponge iron by MIDREX method [6]) is modeled as a Manufacture process in ChemSTEER.

In Table 3 Considered processes for modeling the performance of MIDREX direct reduction furnace are shown which are as follows:

1. Transferring processes of raw iron pellet and its evacuation with auxiliary materials to the spout of the direct reduction furnace.
2. The process of reduction in direct reduction furnaces that operates at high temperatures and processes likely to release suspended particles into workplace atmosphere.
3. Sponge Iron manufacturing process and transition to electric arc unit.

Table 3. Completed processes for the direct reduction iron (DRI) Iranian Ghadir Iron & Steel Company

Operations
Pellet and Lime feeding to DRI
Direct Reduction Iron [DRI]-Midrex method
Sponge Iron production

The amounts of human exposure resulting from the implementation of a mass balance model combined with propagation models, at last results in runing contact estimation models with human resources which their results are estimated with Average Daily Dose, Potential Dose Rate and Lifetime Average Daily Dose for a worker in the output. As it is seen in Table 4, Digital values are these concentrations are respectively 73.6331 mg per kg extrudate per day, for a daily average concentration of 7.547.63 mg per day for daily potential concentration and 41.7043 mg per kg extrudate per day for the length of the process during the lifetime of a worker during the year.

Table 4. Submenu of assessment model Output for Iranian human exposure for Iranian Ghadir Iron & Steel Company

Route of Exposure	Characterization of Results	Total Number of Workers	Exposure Days per Year	Potential Dose Rate (mg/day)	Lifetime Average Daily Dose (mg/kg-day)	Average Daily Dose (mg/kg-day)	Acute Potential Dose (mg/kg-day)	Basis
Inhalation	Out put	1	250	0	0	0	0	User-defined Inhalation
Dermal	High End	1	250	7.547.63	41.7043	73.6331	104.83	EPA/OPPT 2-Hand

In order to enable comparison with intolerable working conditions and what is called irreparable effects caused by exposure and human contact, in the output a value is estimated as an acute potential dose that a suitable measure for comparing estimated daily average potential values and lifetime. This amount is shown in the last column of Table 1 which is estimated 104.83 extrudate mg per kg per day. The estimated average daily concentrations is 73.6333 and the estimated concentration for the period of lifetime of a worker during the year is 41.7043. Both of these concentrations are less than the acute concentration value that this phenomenon would be at first place only confirmation of the relatively good condition of the environment for long-term human contact with the modeled elements (iron) that will be true under certain circumstances of the company operation.

4. Conclusions

ChemSTEER generates screening-level estimates for environmental releases of and worker exposures to a chemical manufactured and used in industrial and commercial operations (workplaces). The worker inhalation exposures estimated by ChemSTEER are expressed in average concentrations, potential daily dose rates, and lifetime-average daily dose rates, among others. The worker dermal exposure estimates for the chemical are also expressed as potential daily dose rates and lifetime-average daily dose rates, among others.

In order to supplementary comparision of the human contacts situation in a long-term workplace environment, here the calculations are not limited only to the acute concentration values by the model with input volumes, process conditions, conditions of side processes, transportation and pollution control in the steel factory. It is worthy to refere to the relevant national or international standards, and do a critical comparison in line with the present case study, the estimated allowed concentration amount By OSHA for iron oxide, is 5 to 10 mg per cubic meter of workplace atmosphere.

The results of this study reveal the need for improvement of the work condition for the well-being of the workers. Generating awareness among the workers to use safety equipments is also another preventive measure that needed to be undertaken. It is recommended that the equipment of all sampling workstations be house kept and corrected. Periodic medical inspection of workers needs to be incorporated as mandatory management programs. The management should take these issues seriously for the well-being of the workers.

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