**Report**

**On**

# Identification and Analysis of Hazardous and Risky Works in Billet based Steel Rolling Mills

**Submitted to**

**Government of Nepal**

**Ministry of Labour, Employment and Social Security**

**Department of Labour and Occupational Safety**

## Occupational Safety and Health Center

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**SMS Environment and Engineering Pvt. Ltd.**
**2079**

## Executive Summary

Occupational Safety and Health (OSH) is a discipline with a broad scope involving many specialized fields. It aims at the promotion and maintenance of the highest degree of physical, mental and social well-being of employees; the prevention among employees of adverse effects on health caused by their working conditions; the protection of employees in their employment from risks resulting from factors averse to health; the placing and maintenance of employees in an occupational environment adapted to physical and mental needs; and the adaptation of work to humans.

Industrial sector has more risk of occupational hazards than other sectors. Industrial occupation may create unsafe work and work environment because of the inherent source of hazards inherent in material, process technologies products. These sources of hazard may pose risk of occurring diseases and happening accidents to the employees within the industrial premises and the public in the vicinity as well as to the general environment. Safe and hazard free work and workplace are required for higher productivity, efficiency, quality of any industrial process various industrial activity like working with machine and equipment, use of electricity, construction works, transportation, use of chemicals, dusty worksites, congested and dark workplace can cause potential to increase potential to increased risk. Therefore, understanding the hazards and risks associated with them is essential for adopting measures to prevent and control the risk.

Rolling mills are considered as an accident prone industries due to its nature of works. Most of the billet-based steel rolling mills converted in self-casting of billet and continuous rolling process. Melting and casting of metal is added the additional hazards and their risk to the workers. Heavy and mechanized material handling, high heating, rollers, working at night and high energy consumption makes these industries very risky to the employees. This study was carried out to identify and analyse the hazards and risky work in billet based steel rolling mills.

For this study, four billet based rolling of Parsa and Bara districts were selected. The production capacity of the visited industries ranged from 300 to 880 TPD and number of workers ranged from 200 to 360. The numbers of female workers in all of the visited industries were comparatively very less than male workers. Many minor accidents and at least one major accident have occurred in all of the visited industries in last fiscal year. There were no deaths recorded due to accidents in any of the visited industries in last fiscal year. The primary data of physical, chemical and mechanical hazards were collected and hazard identification and risk assessment was done by workplace inspection and using risk matrix and monitoring of noise, heat stress and dust was conducted. Recommendations were provided for the identified hazards and for overall improvement of the industries.

The identified physical hazards in the billet based steel industries were noise, heat stress, and electrical hazards. Chemical hazards such as dust, fumes and gases were prominent in the visited industries. Similarly, mechanical hazards such as hazards due to slippery floor, fall, machinery, material storage, internal transportation, passing ways were also identified. Likewise, physiological hazards caused due to not maintaining correct working posture and manual handling of heavy equipment were identified. On the contrary, psychosocial hazard such as use of drugs/alcohol and use of gutkha/tobacco and biological hazards such as bacteria, fungi, parasites, etc. were not found in the visited industries but since the visited industries are located in Terai region, mosquito bites are mostly common during summer.

Monitoring results showed that noise level in melting, rolling, quenching, cutting and utility areas of visited industries were within the workplace noise exposure limit for 8 hrs permissible limits. Similarly, for heat stress, induction furnace and rolling section of all four visited industries were higher than the recommended values. In steel industry 1, quenching and cutting area also showed high heat stress while heat stress of cutting area was within the recommended value. In steel industry 2, heat stress of utility area was high while quenching and cutting section had heat stress within the recommended value. Heat stress of quenching, cutting and utility area of steel 3 were within the recommended value. Similarly, heat stress of quenching and cutting area of steel 4 were within the recommended value while utility area showed slightly high heat stress than the recommended value. As for dust exposure, total dust concentration of Steel 1 was found high as compared to the recommended ACGIH, TLV value while in other three industries, it was found within the recommended value. In case of respirable dust concentration, the monitored values of all visited industries were found higher than the recommended ACGIH, TLV value.

The overall risk of steel industry 1 was found high while other three industries had medium risk. High risk in steel industry 1 is due to poor housekeeping, lack of proper ventilation, lack of safety awareness, high dust level inside industry premises and lack of PPEs provided for workers. Steel industry 2, 3 and 4 had comparatively good housekeeping, safety awareness among workers, had displayed safety signage in the premises, availability of proper ventilation, machine guarding and barricading was done.

All of the visited industries needs to minimize the risk in all of their sections. Based on the observation, hazard identification and risk analysis, recommendations for risk minimization for each industry have been provided.

# Abbreviations

| | |
|---|---|
| ACGIH | American Conference of Governmental Industrial Hygienists |
| dBA | Decibels A weighted |
| DoI | Department of Industry |
| DoLOS | Department of Labour and Occupational Safety |
| HIRA | Hazard Identification and Risk Assessment |
| MSD | Musculoskeletal Disorders |
| OSH | Occupational Safety and Health |
| OSHC | Occupational Safety and Health Center |
| PEL | Permissible Exposure Limit |
| TLV | Threshold Limit Values |
| TMT | Thermo Mechanically Treated |
| TPD | Ton Per Day |
| WBGT | Wet Bulb Globe Temperature |

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# 1. Introduction

## 1.1 Background

Occupational Safety and Health (OSH) is a discipline with a broad scope involving many specialized fields. It aims at the promotion and maintenance of the highest degree of physical, mental and social well-being of employees; the prevention among employees of adverse effects on health caused by their working conditions; the protection of employees in their employment from risks resulting from factors averse to health; the placing and maintenance of employees in an occupational environment adapted to physical and mental needs; and the adaptation of work to humans. Occupational Safety and Health situation is improving at a faster pace in Nepal. Industries can improve their labour productivity if they take into consideration that the employees' safety and health problems arise from the unwanted risk and hazard generated from different processes, using chemicals and raw materials and wastes.

Industrial sector has more risk of occupational hazards than other sectors. Industrial occupation may create unsafe work and work environment because of the inherent source of hazards inherent in material, process technologies products. These sources of hazard may pose risk of occurring diseases and happening accidents to the employees within the industrial premises and the public in the vicinity as well as to the general environment. Safe and hazard free work and workplace are required for higher productivity, efficiency, quality of any industrial process various industrial activity like working with machine and equipment, use of electricity, construction works, transportation, use of chemicals, dusty worksites, congested and dark workplace can cause potential to increase potential to increased risk. Therefore, understanding the hazards and risks associated with them is essential for adopting measures to prevent and control the risk.

Rolling mills are considered as an accident prone industries due to its nature of works. Heavy and mechanized material handling, high heating, rollers, working at night and high energy consumption makes these industries very risky to the employees. Although nowadays many high risky processes are automatized and continuous process, still many accident cases were recorded in Nepal. Billet based steel rolling industries are one of the most hazardous sectors due to nature of work as well as existing working practices in Nepal.

The existing working environment in the Nepalese industries clearly shows the need to improve the conditions. The poor working environment is giving rise to frequent accidents, material damages, low quality product and low productivity. Many types of occupational diseases have also resulted due to long working in unsafe work place and unsafe working environment. This, in turn, results in lower labour productivity and increased medical costs, absenteeism and cost of production. The situation calls for strong need for improvement through giving proper training as well as technical inputs to

the owner /management as well as the work-force of these industries. Different types of hazards present in the industries include:

- chemical hazards, arising from liquids, solids, dusts, fumes, vapours and gases;
- physical hazards, such as noise, vibration, unsatisfactory lighting, radiation, humidity and extreme temperatures;
- mechanical hazard, such as slips, falls, machinery related hazards
- biological hazards, such as bacteria, viruses, infectious waste and infestations;
- psychological hazards resulting from stress and strain;
- physiological hazards (ergonomics) such as badly designed machinery, mechanical devices and tools used by workers, improper seating and workstation design, or poorly designed work practices.

Most of the workers in Nepal face a combination of these hazards at work. For example, it is not difficult to imagine a workplace and worker exposed to chemicals, unguarded machine, poor illumination, noisy machines, hot temperatures, slippery floors, etc. all at the same time and sometimes same person.

Therefore, Government of Nepal, Occupational Safety and Health Center (OSHC) aims to develop a standard document on Hazard identification and risk assessment (HIRA) for this sector. In this regard, this study focuses on identifying and analyzing hazardous and risky works in billet based steel rolling mills and preparing a safe working procedural guideline for this sector. This study will help in addressing the prevailing hazards and minimizing the risk associated with them.

### 1.2 Objective

The main objective of this study program was to conduct identification and analysis of risky works in billet-based steel rolling industries and make safe working procedural guidelines for this sector.

### 1.3 Scope of the Work

The scope of the works were as follows:

- Conduct hazard identification and risk assessment in four billet-based steel rolling mills of Nepal.
- Collection of primary data of physical, chemical and mechanical and physiological hazards.
- Review and assess the policy, legal, regulatory legislation, organization framework and documents related to OSH.
- Analyze the primary and secondary data.
- Preparation of the draft report with recommendation.

### 1.4 Methodology

The following methodology was adopted for the study:

- Site inspection and monitoring in four billet-based Steel Rolling mills of Nepal.
- Primary data of physical, chemical and mechanical and physiological hazards were collected.
- Policy, legal, regulatory legislation, organization framework and documents related to OSH were reviewed and assessed.
- Primary and secondary data were analyzed.
- Hazard identification and risk assessment was done by workplace inspection method and using risk matrix
- Preparation and submission of report with recommendations.

### Risk Assessment

Risk assessment was done by Five Step Process

a. Identify the hazards
b. Identify the people who might be harmed and how
c. Evaluate the risk and decide on precautions
d. The risk is evaluated based on severity and likelihood.

| Severity | | | | | |
|---|---|---|---|---|---|
| 5 | 5 | 10 | 15 | 20 | 25 |
| 4 | 4 | 8 | 12 | 16 | 20 |
| 3 | 3 | 6 | 9 | 12 | 15 |
| 2 | 2 | 4 | 6 | 8 | 10 |
| 1 | 1 | 2 | 3 | 4 | 5 |
| | 1 | 2 | 3 | 4 | 5 |
| | | | Likelihood | | |

### Likelihood

1= extremely unlikely (if there is a 1 in a million chance of hazardous event happening).
2= Unlikely (if there is a 1 in 100,000 chance of hazardous event happening).
3= Possible (if there is a 1 in 10,000 chance of hazardous event happening).
4= Likely (if there is a 1 in 1000 chance of hazardous event happening).
5= Very Probable (if there is a 1 in 100 chance of hazardous event happening).

### Severity

1= Very minor injury
2= first aid injury
3= lost time injury
4- Hospital treatment
5= disabling injury

**Decide on precaution or take action**

| **Risk Rating** | **Action and timescale** |
|---|---|
| 15 and above | **Unacceptable**<br>Work may not start. Additional controls must be introduced to reduce below 9. |
| 9 to 14 | **Tolerable**<br>Additional controls must be introduced as soon as possible and no later than 24 hrs after assessment |
| 5 to 8 | **Tolerable**<br>Must be reduced to below 5 within one week |
| 4 or below | **Acceptable**<br>If simple action can reduce further then must be done within one week |

e. Record the significant findings and implement them
f. Review and update as necessary

# 2. Sectorial Review

## 2.1 Overview of Iron and Steel Industries of Nepal

Iron & steel industry is a largest construction material manufacturing industry that provides large numbers of employment opportunities in Nepal. As per the list published in Department of Industry (DoI) from the beginning to 2076/10/2, there are 83 Iron and Steel industries registered in Nepal, out of which 54 are TMT Bar manufacturing industries. There are 51 TMT Bar Manufacturing industries listed in DoI in four Provinces and DoI has categorized them into 16 large, 21 medium and 14 small scale industries.

Most of the steel rolling mills replaced their reheating of imported billet and rolling technology. After the Government of Nepal increased in import tax on billet, many industries are opting to produce billet on their own as raw materials for producing billet are easily available in the country and it is cost effective. So, industries now having own melting and casting unit. They are using MS scrap, sponge iron, pig iron and manganese as a main raw material. Industries installed induction furnace and replaced the fossils fuel or gasifier based reheating furnace.

The demand for construction materials in Nepal have suddenly sky-rocketed after the government lifted ban on construction of new buildings and houses that was imposed after the earthquake. The annual domestic demand of iron and steels is around 1200,000 metric tons and domestic manufacturers are able to meet this demand. The demand for iron and steel is increasing by 20 percent annually. Manufacturers now run their factories in full-fledged manner as the government has reduced the power cut drastically but the demand is much lower than the production capacity. This will directly increase the production and contribute towards substituting imports from India.

The iron and steel industry has been facing a lot of problems with the main ones being the inadequate supply electricity, deficient connectivity to transport products from one part of the country to another and lack of a skilled workforce. The supply of electricity has improved in recent months, but it is still inadequate according to industrialists. Despite the reduction in power cuts, there is no improvement in the quality due to problems such as low voltage and tripping. The supply system must be upgraded to solve this problem. Meanwhile, the pace of improvement and innovation in steel is also low due to the lack of R&D facilities. Industry can produce better products and manufacture innovative items if the government provides research opportunities and design facilities.

## 2.2 Production Process of TMT

For years, Bamboo has been used by man for construction activities, later it has been replaced by CTD (Cold Twisted Deformed steel rods) or TOR steel rods. The manufacturers adopted the "Cold Twisting Process" in which the naturally cooled rods were twisted by means of motors. Thus the molecular structure of the core steel is weakened. Thus it should not be used for construction activities. Now, the TMT (Thermo Mechanically Treated) steel bars have emerged. Thermo mechanically treated bars are high strength deformed steel bars used in reinforced cement concrete (RCC) work manufactured with the help of advancement of technology. TMT bars are latest production in MS steel bars and have superior properties such as strength, ductility, welding ability, bending ability and highest quality standards at international level.

The TMT Bars are manufactured with a solid and hard outer surface with a pliable inner core. These bars are by default resistant to corrosion and rust, making them for constructing sensitive structures such as high rise residential buildings and bridges in humid areas. Thermo mechanical processing is a metallurgical process that combines mechanical or plastic deformation process like compression or forging, rolling etc. with thermal processes like heat-treatment, water quenching, heating and cooling at various rates into a single process. The quenching process produces a high strength bar from inexpensive low carbon steel. The process quenches the surface layer of the bar, which pressurizes and deforms the crystal structure of intermediate layers, and simultaneously begins to temper the quenched layers using the heat from the bar's core.

The raw material and major machineries used in rolling mills are presented below:

***Raw Materials***

| Online casting and rolling based Industries | Billet Reheating and rolling based industries |
|---|---|
| - MS Scrap<br>- Sponge Iron<br>- Pig Iron<br>- Manganese | - Billete |

***Machines and Equipment***

| Online casting and rolling based Industries | Billet Reheating and rolling based industries |
|---|---|
| - Induction Furnace<br>- Casting line<br>- Hot rolling lines<br>- Quenching Box (TMT Box) | - Reheating Furnace<br>- Hot rolling lines<br>- Quenching Box (TMT Box) |

***Production Process***

TMT bar stands for Thermo Mechanically Treated bar. The production process of TMT bar is described below.

MS Billet:

Sponge iron, scrap, pig iron, flux/ferro and alloy additives are mixed together and batched, melted and casted to produce billet.

TMT:

Heating and Rolling

In this process steel billets/ingots are heated in a reheating furnace and rolled through a sequence of rolling stands which progressively reduces the cross section of billets/ingots to the finished size and shape of the TMT reinforcement bar. This hot rolling process is followed by the quenching and self-tempering process to give the bar more strength and ductility through three steps.

Quenching

A high pressure special water spray system is used on the hot rolled bar to turn its periphery into a martensite zone (hard zone) while keeping its inner surface ferrite perlite.

Self - Tempering

In this stage the bar leaves the quenching system with the temperature of the core being much higher than that of the surface. That makes heat to flow from the core to the surface, making the surface tempered, and a structure that is called **"Tempered Martensite"**.

Atmospheric Cooling

In this final stage, cooling takes place on the cooling bed where the final structure consists of hard outer periphery making it more stronger, more corrosion resistant and fire resistant. The soft inner surface gives the metal ductility (more bendability & elongation), and better fatigue resistance able to withstand natural calamities and other forces better.

The production of quality TMT bar depends on three major factors - quality of raw materials, a properly designed and automated mill, and a well-designed quenching the tempering technology.

**Input and Risks/Hazards in TMT manufacturing process based on Billet (reaheating)**

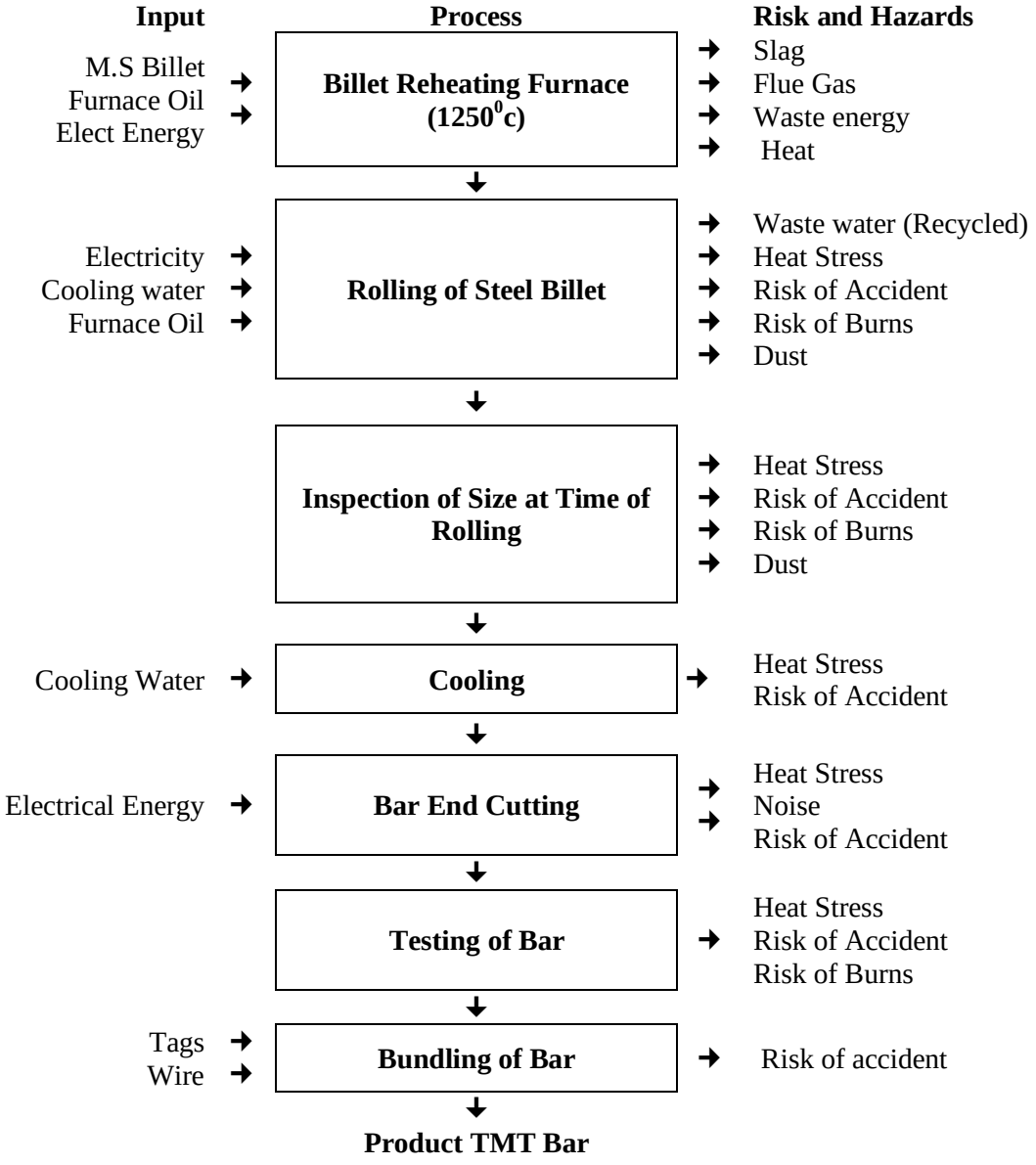
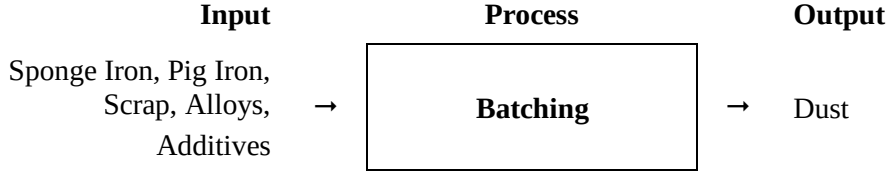



**Figure 2.1: Flowchart of TMT bar making process from billet**

The process flowchart for TMT manufacturing based on scrap (self-melting) is presented below:



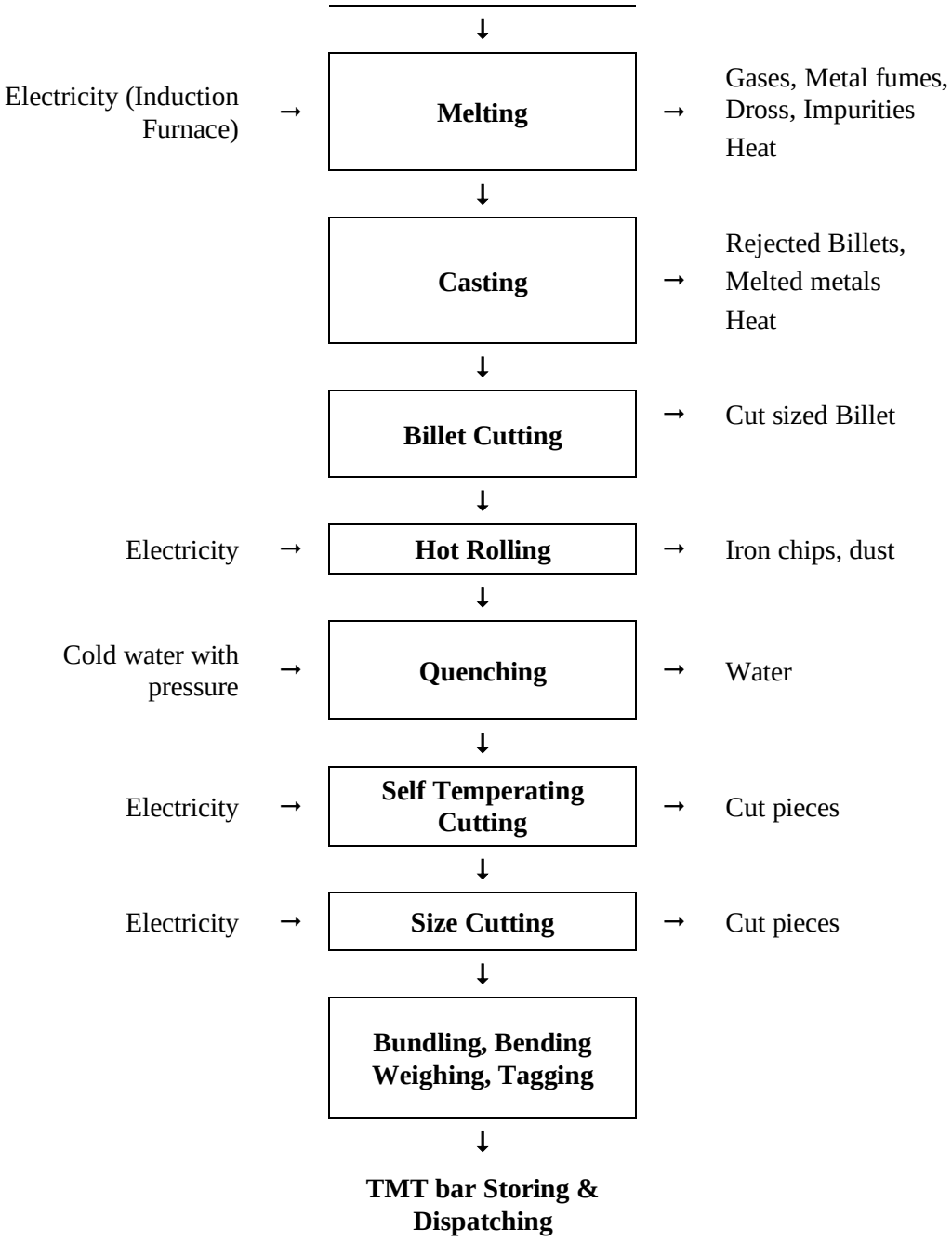



**Figure 2.2: Flowchart of continuous casting to produce billet and TMT**

## 2.3 OSH issues in Steel Industries

*Accidental hazards*

Steel Rolling Mills are considered as an accident prone industries due to its nature of works. Heavy and mechanized material handling, high heating, rollers, working at night and high energy consumption makes these industries very risky to the employees. Power failures, failure of utility services, system failure and defective communication system

are main causes to lead a serious injury at the most rolling mills. Due to the mishandling of the materials, burns due to the heat generation in furnace and improper handling of mechanical transportations within the work areas are also seen in most of the rolling mills. Mechanical transport is essential in iron and steel manufacturing but exposes workers to potential struck-by and caught- between hazards. Overhead travelling cranes are found in almost all areas of steel works which pose a potential accidental hazard. Most large works also rely heavily on the use of fixed-rail equipment and large industrial tractors for transporting materials.

*Health Hazards*

Steel making is one of the noisiest industries. The major sources include shearing machines, rolling mills, and the large fans used for ventilation. Heat exposure is a problem throughout the iron and steel industry, especially in plants located in hot climates. All the rolling mills are located in terai where outside temperature reached more than 40 $^{o}$C in summer season. The danger of heat stress can be reduced by adequate fluid intake, adequate ventilation, the use of heat shields and protective clothing, and periodic breaks for rest or work at a cooler task.

Many activities of rolling mills are also responsible for dust generation. Heated billets when passing through different sized roller slag gets crushed and powdered which generates dust in working environment. Fuel combustion for heating of billets in furnace also generates some ash content and black carbon which also enhance the dust concentration in working environment. Besides the production process, maintenance activities like grinding, welding, machining and cutting job also generates dust. Most of the rolling mills premises are not fully casted or blacktopped, so heavy trucks movement also generates heavy dust cloud to the whole premises. Basically two kinds of dust are generated in all rolling mills. Dust from the billets and machines having the heavy metal which is highly hazardous to the employees. Dust generating from the premises due to vehicle movement it contains heavy metal and high percentages of silica are hazardous to the all employees. Ash and black carbon generated from the furnace also has negative impact to the employees.

## 2.4 Legal provisions for Safety and Health Implementation

There is not any directly implemental rule and regulation that is set especially for Steel Rolling Mills in Nepal. The Labour Act 2074 has some provision on OSH, which explains the whole sectors of industries. The Gazette date of the act is 2074-05-19. The OSH provisions are included in Section 12, from clause 68 to 83. The following Occupational Safety and Health related provisions are covered in Labour Act 2074.

***Clause 68: Safety and Health Policy***

As per the New Labor Act, the entity should formulate the safety and health policy as per the Regulation or Directive. Such policy should be registered with Labor Office. It is also mandatory to self-assessment through labour audit system under the new legislation.

***Clause 69: Responsibility of Employer to Employees***

- To provide appropriate and safe environment for the workers in the workplace,
- To make sure that there shall be no adverse effect to the health and safety of workers during use, operation, storage and transportation of chemical, physical and other materials,
- To provide necessary information, notice or training on OSH matter to the workers including use or operation of the equipment or material in an appropriate language worker understands.
- To keep workplace safe and secure from any probable danger or emergency situation by providing entrance and exit facility to / from workplace.
- To provide personal protection equipment without any cost to the workers

***Clause 70: Responsibility of Employer to visitors***

- Every employer must arrange for the safety and health of every person who walks in and out of the workplace or passes through such workplace.
- In case there is a possibility of having an adverse effect on the safety and health of any person by the operating system of the enterprise, the employer must make an arrangement for giving timely indication or necessary information in that respect.
- It is the duty of employer that she/he manage properly chemical substance or gas or fume and other matter should not affect adversely against any person or environment in general.

***Clause 71: Duties of Responsible Person***

- It shall be the duty of the responsible person controlling any workplace or equipment or material to ensure that such place, equipment, or material is safe for the concerned work and is not adverse to the health of the workers.
- To determine the responsible person of the enterprises, the person having the ownership or control over the workplace or equipment or material. The word also denote to the person by an agreement, having ownership or control over it.

***Clause 72: Responsibility of Producer, Importer and Suppliers***

- To determine suitable way of using or operating any equipment or material without affecting the safety and health of the workers adversely.
- To conduct research, test or to examine the possibility of identifying the risk from the use of such equipment or material or the adverse effect it may have on the safety and health of the workers or the possibility of minimizing or eliminating such risk.

- To provide information in relation to the purpose, use and operation of any equipment or material, the ways of minimizing their adverse effect on the safety and health of the workers and also the suitable method of using any material for the safety and health of the workers.
- The person who manufactures or installs any equipment must ensure that such equipment manufactured or installed for the use of the workplace, if used properly, will not be harmful to the safety and health of the workers.
- If it is found that the equipment or material is not used in accordance with the relevant information or instruction provided by the manufacturer or supplier in relation to their use, such equipment or material, for the purpose of this section, shall be considered to have been used inappropriately.
- The manufacturer, importer or supplier of any chemical substance to be used in the workplace must have material or Chemical Safety Data Sheet related to such chemical substance including other details as prescribed.

***Clause 73: Duties of Employees***

- A worker must not work carelessly or intentionally whereby the risk of adversely affecting the health of others or his/her own health
- A worker must provide necessary cooperation to the employer or any other person for the fulfillment of the obligations mentioned in the law.
- A worker must operate and use the workplace, equipment or material safely and carefully as per the instructions given.
- To obtain the information in relation to his or her work and use of chemical, material and equipment.
- Use personal safety equipment as provided by employer, violation of which shall be punishable under disciplinary action.

***Clause 74: Formation of Safety and Health Committee***

Where 20 or more workers are engaged in work in an entity, employer shall constitute a safety and health committee having the representation of Workers and Management. The committee shall perform its powers, functions and duties as follows:

- To manage OSH matter in the workplace and enforcement effectively
- To review the arrangement of OSH periodically
- To inform the employer and labour office about the shortcomings or deterioration of quality in the arrangement if it is noticed
- To review the OSH policy of the establishment

***Clause 75: Protection from Punishment***

- In case any person carelessly or intentionally violates the provisions of the Act or the Rules made here under in respect of safety and health of the workers and as a result of which any person dies or is incapacitated or injured, the person responsible for such act, the punishment in accordance to the existing law, and if

such punishment is not mentioned in any law, the person shall be punished with an imprisonment of up to two years including recovery of compensation to the victim.

- In case, any establishment is doing such crime, the imprisonment in normally imposed to the responsible person or such person is not identify, the chief executive officer shall be send to the jail and fine and compensation shall be recovered by the establishment.

***Clause 76: Stoppage of work in case of immediate danger***

- Where there is a reasonable ground to believe that if a particular work is not stopped, it may injure any worker or any person or cause risk or may have harmful effect on the health of the workers or may damage any equipment, the worker involved in such work shall inform of the same to the employer or responsible person.
- The concerned worker may halt the work if the employer is not available and inform them as soon as possible.
- Upon receipt of the information the employer shall investigate the matter and accordingly make a suitable safety arrangement to avoid such risk and direct the workers to continue the work if it is possible to do so.
- The employer, subject to the scope of employment contract, may engage the workers in any other risk free work during the stoppage of work.

***Clause 77: Direction to stop the work by Labour Office***

- During the inspection or information received through any other source, the Labour Office may order to stop work in case it is believes that an immediate danger or risk has arisen in a workplace.
- The Office must disclose the causes and basis of such risk while issuing the direction to the employer.
- The Labour Office may issue an order prohibiting the use of such equipment and work place or any part of it may be sealed so that it is not used.

***Clause 78: Special provisions of Occupational Safety and Health***

- Eyes Safety
- Chemical Safety
- Boiler Operation Safety
- Machine Guarding
- Weight Lifting
- Others

***Clause 79: Provide Information***

If any accident takes place in the workplace or any worker or person dies because of the accident or is injured or suffers from occupational disease, the employer must inform the Labour Office immediately.

***Clause 80: Communicable Diseases Control Management***

- The employer must make necessary arrangement to prevent communicable disease in the workplace.
- Any worker suffering from any communicable disease may be prohibited from attending the work during the period of medical treatment.
- In case the sick leave is not sufficient for the medical treatment, such worker must be granted additional leave till the period of treatment.
- It is duty of concern worker stay in leave during the treatment period.

***Clause 81: Work for Pregnant Women***

- In case any female worker is pregnant, the employer must be informed about it.
- After receiving information, normally, such pregnant worker must not be engaged in the work that adversely affects her pregnancy.

***Clause 82: Occupational Diseases Treatment***

- In case any worker contracts any occupational disease while working in any enterprise, the medical expense as prescribed or in case if the worker is incapable of working as a result of such disease, the compensation for that must be born by such enterprise where the worker worked and contracted the disease.
- The establishment shall not be required to bear the medical expense or compensation if the medical expense or compensation as is to be borne by Social Security Fund.

***Clause 83: Provide Direction***

- The Office shall conduct a sudden or periodic inspection in order to verify whether the employer has made any arrangement or not in relation to the safety and health of the workers required by the Act or the existing law.
- During the inspection of workplace, if it is found that the employer has failed to arrange appropriately, the office shall provide time frame with a direction to make required arrangement to the employer.
- However, if there is a possibility of immediate danger to the safety and health of the workers or other persons in absence of such arrangement, the Office may issue an order to make such arrangement immediately stating the reasons for the same.

## 3. Observations and Findings

Four rolling mills were visited to identify the risks and hazards. Two industries were located in Parsa and remaining two were located in Bara.

**General Information of visited rolling mills**

The information of visited rolling mills is presented in the table below:

**Table 3.1: General information of the visited industries**

| SN | Steel Industries | Location | Capacity Tons per day (TPD) | Major Raw Materials | Major Products | Energy used |
|---|---|---|---|---|---|---|
| 1 | Steel 1 | Bara | 300 | MS Scrap, Sponge Iron, Pig Iron, Manganese | MS Billet and TMT | Electricity and Diesel |
| 2 | Steel 2 | Parsa | 560 | | | |
| 3 | Steel 3 | Bara | 500 | | | |
| 4 | Steel 4 | Parsa | 880 | | | |

The production capacity of the visited industries ranged from 300 to 880 TPD. The major raw material used are MS scrap, sponge iron, pig iron and chemicals such as manganese and hydrochloric acid. All of the visited industries used electricity and diesel for energy consumption.

*Employment*

The numbers of workers in the visited industries are presented in the table below:

**Table 3.2: No of workers in visited steel industries**

| SN | Steel Industries | Number of Workers | | | Nationality of Workers | |
|---|---|---|---|---|---|---|
| | | Male | Female | Total | Nepali | Indian |
| 1 | Steel 1 | 230 | 20 | 250 | 120 | 130 |
| 2 | Steel 2 | 175 | 25 | 200 | 115 | 85 |
| 3 | Steel 3 | 276 | 24 | 300 | 175 | 125 |
| 4 | Steel 4 | 340 | 20 | 360 | 200 | 160 |

The total number of workers in the visited steel industries ranged from 200 to 360. The numbers of female workers in all of the visited industries were comparatively very less than male workers. Steel industry requires heavy lifting and risky works, which is why there are less female workers in this sector. The visited steel industries have provided employment to Nepalese as well as Indian citizen.

*Implementation of mandatory provisions of the Labour Law regarding OSH*

The implementation status of mandatory provisions of the labour law regarding OSH in the visited four industries is presented in the table below:

**Table 3.3: Implementation status of labour law regarding OSH**

| Mandatory Provisions of Labour Laws | Steel 1 | | Steel 2 | | Steel 3 | | Steel 4 | |
|---|---|---|---|---|---|---|---|---|
| | Yes | No | Yes | No | Yes | No | Yes | No |
| Safety and Health Policy formulation and display | | ✓ | | ✓ | | ✓ | | ✓ |
| Responsible person declaration | | ✓ | | ✓ | | ✓ | | ✓ |
| Formation of Safety and Health Committee | ✓ | | ✓ | | ✓ | | ✓ | |
| Labour Audit | ✓ | | ✓ | | ✓ | | ✓ | |
| Reporting of Accident within 7 days | | ✓ | | ✓ | | ✓ | | ✓ |
| Provision of non-workers safety | | ✓ | | ✓ | | ✓ | | ✓ |
| Child Care Center | | ✓ | | ✓ | | ✓ | | ✓ |
| Canteen | | ✓ | | ✓ | | ✓ | | ✓ |
| Rest Room | | ✓ | | ✓ | | ✓ | | ✓ |
| First Aid | ✓ | | ✓ | | ✓ | | ✓ | |

*Accident Records in Visited Industries*

Steel industries are considered as accident-prone industry. The accident records of FY 2078/79 of the visited industries are presented in table below.

**Table 3.4: Accident records in visited industries**

| SN | Steel Industries | Minor Accident | Major Accident | Death | Total |
|---|---|---|---|---|---|
| 1 | Steel 1 | 120 | 2 | 0 | 122 |
| 2 | Steel 2 | 98 | 1 | 0 | 99 |
| 3 | Steel 3 | 76 | 1 | 0 | 77 |
| 4 | Steel 4 | 92 | 1 | 0 | 93 |

Many minor accidents and at least one major accident have occurred in all of the visited industries in last fiscal year. There were no deaths recorded due to accidents in any of the visited industries in last fiscal year.

## 3.1 Hazard Identification

### *3.1.1 List of overall hazards in visited industries*

Hazards were identified in all four visited industries and is shown in the following table.

**Table 3.5: Hazard identification in visited industries**

| Hazard | Steel 1 | | Steel 2 | | Steel 3 | | Steel 4 | |
|---|---|---|---|---|---|---|---|---|
| | Yes | No | Yes | No | Yes | No | Yes | No |
| **Physical** | | | | | | | | |
| Noise/Vibration | ✓ | | ✓ | | ✓ | | ✓ | |
| Heat | ✓ | | ✓ | | ✓ | | ✓ | |
| Low illumination | | ✓ | | ✓ | | ✓ | | ✓ |
| Electricity | ✓ | | ✓ | | ✓ | | ✓ | |
| **Chemical** | | | | | | | | |
| Dust | ✓ | | ✓ | | ✓ | | ✓ | |
| Fumes | ✓ | | ✓ | | ✓ | | ✓ | |
| Gases | ✓ | | ✓ | | ✓ | | ✓ | |
| **Mechanical** | | | | | | | | |
| Induction Furnace | ✓ | | ✓ | | ✓ | | ✓ | |
| Floor (slippery) | ✓ | | ✓ | | ✓ | | ✓ | |
| Fall | ✓ | | ✓ | | ✓ | | ✓ | |
| Machine and production line | ✓ | | ✓ | | ✓ | | ✓ | |
| Material storage and handling | ✓ | | ✓ | | ✓ | | ✓ | |
| Lifting and Internal transportation | ✓ | | ✓ | | ✓ | | ✓ | |
| Working floors | ✓ | | ✓ | | ✓ | | ✓ | |
| Overhead cranes and Passing ways | ✓ | | ✓ | | ✓ | | ✓ | |
| **Physiological** | | | | | | | | |
| Working posture | ✓ | | ✓ | | ✓ | | ✓ | |
| Long duty hours | | ✓ | | ✓ | | ✓ | | ✓ |
| Manual handling of heavy equipment | ✓ | | ✓ | | ✓ | | ✓ | |
| **Psychosocial** | | | | | | | | |
| Use of drugs/alcohol | | ✓ | | ✓ | | ✓ | | ✓ |
| Using tobacco/gutkha | | ✓ | | ✓ | | ✓ | | ✓ |
| Poor management | | ✓ | | ✓ | | ✓ | | ✓ |
| Low salary | | ✓ | | ✓ | | ✓ | | ✓ |
| Rest and recreational | | ✓ | | ✓ | | ✓ | | ✓ |
| **Biological** | | | | | | | | |
| Bacteria | | ✓ | | ✓ | | ✓ | | ✓ |

| Hazard | Steel 1 | | Steel 2 | | Steel 3 | | Steel 4 | |
|---|---|---|---|---|---|---|---|---|
| | Yes | No | Yes | No | Yes | No | Yes | No |
| Fungi | | ✓ | | ✓ | | ✓ | | ✓ |
| Parasite | | ✓ | | ✓ | | ✓ | | ✓ |
| Snake | | ✓ | | ✓ | | ✓ | | ✓ |
| Mosquito | ✓ | | ✓ | | ✓ | | ✓ | |

**Physical hazard**

The identified physical hazards in the billet based steel industries were noise, heat stress, and electrical hazards. Steel making is one of the noisiest industries. The major sources include shearing machines, rolling mills, and the large fans used for ventilation. Causes of hearing loss other than noise include burns to the eardrum from particles of slag, scale, perforation of the drum from intense impulse noise and trauma from falling or moving objects. From the inlet of the furnace and until the final cutting, heat stresses occurs due nature of industry. Exposure to heat radiation, open flaming from openings causes serious heat problems to all workers. Excessive heat can cause dehydration, severe burns and heatstroke.

**Chemical hazard**

Chemical hazards such as dust, fumes and gases were prominent in the visited industries. Dust and fumes are generated at many points. Dusts and fumes from iron ore or ferrous metals may cause pulmonary fibrosis and pneumoconiosis. Carcinogens found in emissions may cause lung cancers.

**Mechanical hazard**

Mechanical hazards such as hazards due to slippery floor, fall, machinery, material storage, internal transportation, passing ways were identified in the visited industries.

**Physiological hazard**

Physiological hazards caused due to not maintaining correct working posture and manual handling of heavy equipment were identified. Musculoskeletal injuries are common in steel making. Despite the introduction of mechanization and assistive devices, manual handling of large, bulky and/or heavy objects remains a frequent necessity which may lead to poor ergonomic condition.

**Psychosocial hazard**

On the contrary, psychosocial hazard such as use of drugs/alcohol and use of gutkha/tobacco were not found. Other potential hazard related to organisational setup, organisational behaviour, leave provision, recreation for workers and accommodation were not found.

**Biological hazard**

Biological hazards such as bacteria, fungi, parasites, etc. were not found in the visited industries but since the visited industries are located in Terai region, mosquito bites are mostly common during summer.

### *3.1.2 Specific Hazards responsible for Accident and Hazards in selected sections of the visited industries*

Hazards related to accidents and health problems were also identified in selected sections of visited industries. In all four visited industries, hazards responsible for accidents and health problems were similar as production of all industries are same.

**Table 3.6: Hazards responsible for accidents in selected sections**

| **Hazards Related to Accidents** | | | | |
|---|---|---|---|---|
| ***Melting Section (Induction Furnace)*** | ***Rolling Section*** | ***Quenching Section*** | ***Cutting Section*** | ***Utility*** |
| - Explosion<br>- High Heat<br>- Molten metal spattering<br>- Working at height<br>- Electricity<br>- Poor housekeeping | - High Heat<br>- Hot metals<br>- Electricity<br>- Complex mechanical rolling lines<br>- Overhead crane | - Hot metals<br>- High heat<br>- Electricity<br>- Complex mechanical rolling lines<br>- High pressure water | - Cutting lines<br>- Electricity<br>- Hot TMT | - Tools and equipment<br>- Maintenance<br>- Slippery floor<br>- Spillage<br>- Electricity<br>- Overhead crane<br>- Lifter/ hoist |

The observed hazards responsible for accidents in melting section of visited industries were explosion, high heat, splattering of molten metal, working at height, electricity and poor housekeeping. Similarly, high heat, hot metal, electricity, complex mechanical rolling lines and overhead cranes were observed in rolling section as hazards that can cause accidents. In case of quenching section, similar hazards were observed as rolling section with addition of high pressure water as hazard. In cutting section, cutting lines, electricity and hot TMT were the observed hazards while in utility section, tools and equipment, maintenance, slippery floor, spillage, electricity, overhead crane and lifter were the hazards that could cause accidents.

**Table 3.7: Hazards responsible for health problems in selected sections**

| **Hazards Related to Health Problems** | | | | |
|---|---|---|---|---|
| ***Melting Section (Induction Furnace)*** | ***Rolling Section*** | ***Quenching Section*** | ***Cutting Section*** | ***Utility*** |
| - Metal fumes<br>- Gases<br>- Heat<br>- Smoke<br>- Light | - Heat<br>- Noise | - Heat<br>- Noise<br>- Water vapours | - Dust<br>- Noise | - Smoke<br>- Gases<br>- Noise |

The observed health hazards in melting section of visited industries were metal fumes, gases, heat, smoke and light. Likewise, heat and noise in rolling section; heat, noise and water vapour in quenching section; dust and noise in cutting section; and smoke, gas and noise in utility section were observed in all visited industries as hazards which are responsible for health problems.

### 3.2 Workplace Monitoring and Observation

**Noise**

During the visit it was observed that many processes of rolling mill generate high noise level. Shearing of billet generates the impact noise while other process generates the continuous noise. High capacity of fans, burners and rollers were mainly responsible to generate high noise level in rolling mills. All involved workers were exposed with the high noise levels. The following noise data were measured with the help of digital noise level meter.

**Table 3.8: Noise level, Level of Equivalent (Leq) monitoring in visited industries**

| Noise Level | Location/Section | Steel 1 | Steel 2 | Steel 3 | Steel 4 |
|---|---|---|---|---|---|
| Leq in dBA | Induction Furnace | 88.3 | 87.2 | 85.4 | 88.1 |
| | Rolling Mill | 87.2 | 86.7 | 84.3 | 85.1 |
| | Quenching | 88.2 | 85.4 | 83.7 | 84.2 |
| | Cutting | 84.1 | 84.3 | 82.1 | 83.7 |
| | Utility Area | 83.4 | 82.1 | 79.2 | 79.7 |
| **Permissible Exposure Limit (PEL), dBA** | | ***90 dBA for 8 hrs per day***<br>Hearing Protection shall be mandatory above 85 dBA | | | |

Noise level in melting, rolling, quenching, cutting and utility areas of visited industries were within the workplace noise exposure limit for 8 hrs permissible limits.

**Heat Stress**

Steel is rolled after heating to its melting temperature in furnace. Pulverized coal and furnace oil is used as fuel. TMT production needs water charging in hot bars, which generates vapors and increase the humidity in working environment. All the selected rolling mills are located in terai where outside temperature reach to 40$^{o}$C in summer season. The recommended value of Wet Bulb Globe Temperature (WBGT) for moderate works having 50% works and 50% rest is 29.4$^{o}$C. The measured WBGT value in visited industries are as follows:

**Table 3.9: Heat stress monitoring in visited industries**

| Heat Stress | Location/Section | Steel 1 | Steel 2 | Steel 3 | Steel 4 |
|---|---|---|---|---|---|
| WBGT, $^{o}$C | Induction Furnace | 34.5 | 36.1 | 34.3 | 32.4 |
| | Rolling Mill | 32.1 | 29.7 | 31.3 | 31.2 |
| | Quenching | 29.7 | 28.6 | 28.2 | 27.4 |
| | Cutting | 27.7 | 28.3 | 26.4 | 26.1 |
| | Utility Area | 30.2 | 31.2 | 29.1 | 29.5 |
| TLV of ACGIH | | 29.4 $^{o}$C | | | |

Workers of the rolling mills are exposed with the high heat and humidity. It was found that the measured WBGT value in induction furnace and rolling section of all four visited industries were higher than the recommended values. In steel industry 1, quenching and cutting area also showed high heat stress while heat stress of cutting area was within the recommended value. In steel industry 2, heat stress of utility area was high while quenching and cutting section had heat stress within the recommended value. Heat stress of quenching, cutting and utility area of steel 3 were within the recommended value. Similarly, heat stress of quenching and cutting area of steel 4 were within the recommended value while utility area showed slightly high heat stress than the recommended value.

**Dust Exposure**

Many activities of rolling mills are responsible for dust generation. Heated billets when passing through different sized roller slag gets crushed and powdered which generates dust in working environment. Fuel combustion for heating of billets in furnace also generates some ash content and black carbon which also enhance the dust concentration in working environment. Besides the production process maintenance activities like grinding, welding, and cutting process also generates dust.

Basically two kinds of dust are generated in all rolling mills. Dust from the billets and machines contain heavy metal which is highly hazardous to the employees. Dust from the premises due to vehicle movement contains heavy metal and high percentages of silica, both theses constituents are hazardous to the all employees. Ash and black carbon generated from the furnace also have negative impact to the employees. The dust concentration was measured in induction furnace area of all visited industries. The obtained value of dust are as follows:

**Table 3.10: Dust exposure in induction furnace area of visited industries**

| S.N | Steel Industry | Total Dust | | Respirable Dust | |
|---|---|---|---|---|---|
| | | Concentration mg/m$^3$ | ACGIH TLV mg/m$^3$ | Concentration mg/m$^3$ | ACGIH TLV mg/m$^3$ |
| 1 | Steel 1 | 30.2 | 10 | 18.7 | 3 |
| 2 | Steel 2 | 9.5 | | 3.4 | |
| 3 | Steel 3 | 7.2 | | 3.1 | |
| 4 | Steel 4 | 9.7 | | 3.4 | |

The total dust concentration of Steel 1 was found high as compared to the recommended ACGIH, TLV value of 10 mg/m$^3$. In rest of the three steel industries, the total dust concentration was within the recommended TLV value.

In case of respirable dust concentration, the monitored values of all visited industries were found higher than the recommended ACGIH, TLV value of 3 mg/m$^3$.

**Existing Control Measures**

The existing control measures in the visited industries are listed below:

**Table 3.11: Existing control measures in the visited industries**

| S.N | Industry | Control measures adopted |
|---|---|---|
| 1. | Steel 1 | - Partial machine guarding and barricading<br>- Portable fire extinguisher installed |
| 2. | Steel 2 | - Dust and fumes collection system<br>- Temperature sensor control<br>- Computerised control system<br>- Machine guarding and barricading<br>- Safety signage<br>- Safety awareness<br>- Safety responsible persons<br>- Fire fighting system |
| 3. | Steel 3 | - Dust and fumes collection system<br>- Temperature sensor control<br>- Computerised control system<br>- Machine guarding and barricading<br>- Safety signage<br>- Safety awareness<br>- Safety responsible persons<br>- Fire fighting system |
| 4. | Steel 4 | - Dust and fumes collection system<br>- Temperature sensor control<br>- Computerised control system<br>- Machine guarding and barricading<br>- Safety signage |

| | | |
|---|---|---|
| | | - Safety awareness<br>- Safety responsible persons<br>- Fire fighting system |

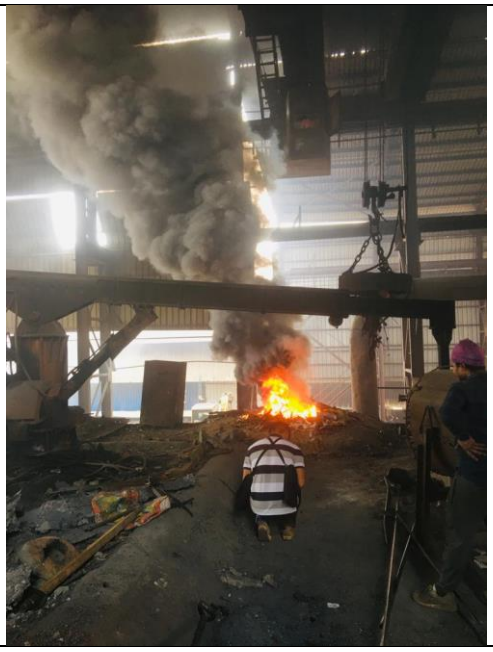
**Other Observations of Visited Industries**

Some observations of the visited industries are presented below:

**1. Steel Industry 1**

The following were observed in steel industry 1:

- High level of dust exposure from a different source
- High exposure to heat
- High noise level
- Lack of proper ventilation for smoke
- No PPEs provided to workers
- Poor house keeping
- Fire extinguisher installed
- No Safety signage displayed
- Dusty road condition

| | |
|---|---|
|  |  |
| Lack of ventilation for smoke | Worker without PPE |

| | |
|---|---|
|  |  |
| Poor housekeeping | Dusty internal roads |
|  |  |
| Fire extinguisher | Oxygen cylinder |

**2. Steel Industry 2**

The following were observed in steel industry 2:

- Proper ventilation for smoke
- PPEs provided to worker
- Good house keeping
- Fire fighting system present
- Safety signage displayed
- Machine guarding and barricading done



Display of safety signage

Poor housekeeping

Internal roads

### 3. Steel Industry 3

The following were observed in steel industry 3:

- Proper ventilation for smoke
- PPEs provided to worker
- Good house keeping
- Fire fighting system present
- Safety signage displayed
- Muddy road condition

| | |
|---|---|
|  |  |
| Working area with ventilation | Rolling section |
|  |  |
| Good housekeeping | Muddy internal roads |

| | |
|---|---|
|  |  |
| Fire extinguisher | Workers with PPE |

**4. Steel Industry 4**

The following were observed in steel industry 4:

- Proper ventilation for smoke
- PPEs provided to worker
- Good house keeping
- Fire fighting system present
- Safety signage displayed
- Gravel road

| | |
|---|---|
|  |  |

| Control room | Well ventilated working area |
|---|---|
|  |  |
| Raw material storage area | |

### 3.3 Risk Assessment

Risk assessment was carried out using workplace inspection method and risk matrix. Workplace observation and expert opinions were taken into consideration in risk assessment process. The risk matrix was developed based on the observations and monitoring of data of noise level, heat stress and dust level. Risk matrix of visited industries was developed and is shown in the table below:

**Table 3.12: Risk matrix of all working locations in steel industries**

| Industry | Melting section | | | Rolling Section | | | Quenching Section | | | Cutting Section | | | Utility | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S | L | RS | S | L | RS | S | L | RS | S | L | RS | S | L | RS |
| Steel 1 | 5 | 4 | 20 | 5 | 3 | 15 | 3 | 3 | 9 | 3 | 3 | 9 | 4 | 3 | 12 |
| Steel 2 | 5 | 2 | 10 | 5 | 2 | 10 | 3 | 2 | 6 | 3 | 2 | 6 | 4 | 2 | 8 |
| Steel 3 | 5 | 2 | 10 | 5 | 2 | 10 | 3 | 2 | 6 | 3 | 2 | 6 | 4 | 2 | 8 |
| Steel 4 | 5 | 3 | 15 | 5 | 2 | 10 | 3 | 2 | 6 | 3 | 2 | 6 | 4 | 2 | 8 |

*(S: Severity; L: Likelihood; RS: Risk Score)*

**Comparative Analysis of Risk**

The comparative analysis of risk of all visited industries was done and is presented in the following table:

**Table 3.13: Comparative analysis of risk in visited steel industries**

| S.N | Industry | Melting section | Rolling Section | Quenching Section | Cutting Section | Utility |
|---|---|---|---|---|---|---|
| 1. | Steel 1 | High | High | High | High | High |
| 2. | Steel 2 | High | Medium | Medium | Medium | Medium |

| S.N | Industry | Melting section | Rolling Section | Quenching Section | Cutting Section | Utility |
|---|---|---|---|---|---|---|
| 3. | Steel 3 | High | Medium | Medium | Medium | Medium |
| 4. | Steel 4 | High | Medium | Medium | Medium | Medium |

All of the visited industries showed high risk in the melting section. From the risk matrix, steel industry 1 showed high risk in rolling section whereas, rest of the three industries showed medium risk in rolling section. Similarly, in quenching, cutting and utility section, high risk was found in steel industry 1 and medium risk in rest of the three industries.

The overall risk of steel industry 1 was found high while other three industries had medium risk. High risk in steel industry 1 is due to poor housekeeping, lack of proper ventilation, lack of safety awareness, high dust level inside industry premises and lack of PPEs provided for workers. Steel industry 2, 3 and 4 had comparatively good housekeeping, safety awareness among workers, had displayed safety signage in the premises, availability of proper ventilation, machine guarding and barricading was done.

All of the visited industries need to minimize the risk in all of their sections. Based on the observation, hazard identification and risk analysis, recommendations for risk minimization for each industry is provided below.

## Recommendation for Visited Industries

*1. Steel Industry 1*

Some recommendations for risk minimization of steel industry 1 are listed below:

- Conduct Hazard Identification and Risk Assessment (HIRA) and based on its risk assessment comply with Hierarchy of control measures (Elimination, Substitution, Engineering control, administrative control, Personal Protective Equipment)
- Install smoke and fumes collection system in all induction furnace
- Install temperature sensor control and robot control system in induction furnace
- Install complete machine guarding and barricading
- Make compulsory to prove safety awareness to all workers
- Comply with the labour act and rules
- Implement and display Occupational Safety and Health Policy
- Occupational Safety and Health Committee shall ensure and monitor OSH policy is effectively implemented
- Prepare and implement emergency preparedness plan
- Implement proper Ergonomics and Streamline material flow
- Display safety signages at workplace
- Display Dos and don’ts signage at workplace

- Keep barriers and guards for all moving drives
- Provide proper illumination level in all working areas
- Improve housekeeping
- Avoid slipperiness by regularly cleaning the floor
- Install Preventive Maintenance System
- Install Push and Pull Type and Local Exhaust Ventilation
- Maintain internal roads
- Install 25 kg $CO_2$ based and 25kg trolley based Dry Chemical Powder based fire extinguishers
- Regular monitoring of fire extinguishers
- Install emergency siren
- Provide orientation training on OSH as per requirement.
- Provide accidental insurance to employees
- Keep First Aid kit at working place
- Provide proper and suitable Personnel Protective Equipment (PPE) such as safety gloves, ear plug, safety helmet, safety shoes, safety boots, mask, etc. to employees as per requirement

*2. Steel Industry 2*

Some recommendations for risk minimization of steel industry 2 are listed below:

- Conduct Hazard Identification and Risk Assessment (HIRA) and based on its risk assessment comply with Hierarchy of control measures (Elimination, Substitution, Engineering control, Administrative control, Personal Protective Equipment)
- Comply with the labour act and rules
- Implement and display Occupational Safety and Health Policy
- Occupational Safety and Health Committee shall ensure and monitor OSH policy is effectively implemented
- Prepare and implement emergency preparedness plan
- Implement proper Ergonomics and Streamline material flow
- Improve further housekeeping
- Maintain internal roads
- Install 25 kg $CO_2$ based and 25kg trolley based Dry Chemical Powder based fire extinguishers
- Regular monitoring of fire extinguishers
- Install emergency siren
- Provide orientation training on OSH as per requirement.
- Provide accidental insurance to employees
- Provide proper and suitable Personnel Protective Equipment (PPE) such as safety gloves, ear plug, safety helmet, safety shoes, safety boots, mask, etc. to employees as per requirement

*3. Steel Industry 3*

Some recommendations for risk minimization of steel industry 1 are listed below:

- Conduct Hazard Identification and Risk Assessment (HIRA) and based on its risk assessment comply with Hierarchy of control measures (Elimination, Substitution, Engineering control, Administrative control, Personal Protective Equipment)
- Comply with the labour act and rules
- Implement and display Occupational Safety and Health Policy
- Prepare and implement emergency preparedness plan
- Implement proper Ergonomics and Streamline material flow
- Display safety signages at workplace
- Display Dos and don'ts signage at workplace
- Keep barriers and guards for all moving drives
- Maintain internal roads concrete
- Install 25 kg $CO_2$ based and 25kg trolley based ABC type fire extinguishers
- Provide orientation training on OSH as per requirement.
- Provide accidental insurance to employees
- Provide proper and suitable Personnel Protective Equipment (PPE) such as safety gloves, ear plug, safety helmet, safety shoes, safety boots, mask, etc. to employees as per requirement

*4. Steel Industry 4*

Some recommendations for risk minimization of steel industry 1 are listed below:

- Conduct Hazard Identification and Risk Assessment (HIRA) and based on its risk assessment comply with Hierarchy of control measures (Elimination, Substitution, Engineering control, Administrative control, Personal Protective Equipment)
- Comply with the labour act and rules
- Implement and display Occupational Safety and Health Policy
- Prepare and implement emergency preparedness plan
- Implement proper Ergonomics and Streamline material flow
- Display safety signages at workplace
- Display Dos and don'ts signage at workplace
- Keep barriers and guards for all moving drives
- Improve further housekeeping
- Avoid slipperiness by regularly cleaning the floor
- Provision of two emergency exit at workstation
- Install 25 kg $CO_2$ based and 25kg trolley based ABC type fire extinguishers
- Install emergency siren
- Provide orientation training on OSH as per requirement.
- Provide accidental insurance to employees

- Keep First Aid kit at working place
- Provide proper and suitable Personnel Protective Equipment (PPE) such as safety gloves, ear plug, safety helmet, safety shoes, safety boots, mask, etc. to employees as per requirement

# 4. Conclusion and Recommendations

## 4.1 Conclusion

Rolling mills are considered as an accident prone industries due to its nature of works. Heavy and mechanized material handling, high heating, rollers, working at night and high energy consumption makes these industries very risky to the employees. The study was conducted in four billet based rolling mills of Parsa and Bara districts to identify the impacts and analyse hazardous and risky works. The production capacity of the visited industries ranged from 300 to 880 TPD and number of workers ranged from 200 to 360. The numbers of female workers in all of the visited industries were comparatively very less than male workers. Many minor accidents and at least one major accident have occurred in all of the visited industries in last fiscal year. There were no deaths recorded due to accidents in any of the visited industries in last fiscal year. Hazard identification, risk analysis and monitoring of noise, heat stress and dust in the selected rolling mills were conducted.

The identified physical hazards in the billet based steel industries were noise, heat stress, and electrical hazards. Chemical hazards such as dust, fumes and gases were prominent in the visited industries. Similarly, mechanical hazards such as hazards due to slippery floor, fall, machinery, material storage, internal transportation, passing ways were also identified. Likewise, physiological hazards caused due to not maintaining correct working posture and manual handling of heavy equipment were identified. On the contrary, psychosocial hazard such as use of drugs/alcohol and use of gutkha/tobacco and biological hazards such as bacteria, fungi, parasites, etc. were not found in the visited industries but since the visited industries are located in Terai region, mosquito bites are mostly common during summer. Hazards related to accidents and health problems were also identified in selected sections of visited industries.

Monitoring results showed that noise level in melting, rolling, quenching, cutting and utility areas of visited industries were within the workplace noise exposure limit for 8 hrs permissible limits. Similarly, for heat stress, induction furnace and rolling section of all four visited industries were higher than the recommended values. In steel industry 1, quenching and cutting area also showed high heat stress while heat stress of cutting area was within the recommended value. In steel industry 2, heat stress of utility area was high while quenching and cutting section had heat stress within the recommended value. Heat stress of quenching, cutting and utility area of steel 3 were within the recommended value. Similarly, heat stress of quenching and cutting area of steel 4 were within the recommended value while utility area showed slightly high heat stress than the recommended value. As for dust exposure, total dust concentration of Steel 1 was found high as compared to the recommended ACGIH, TLV value while in other three industries, it was found within the recommended value. In case of respirable dust

concentration, the monitored values of all visited industries were found higher than the recommended ACGIH, TLV value.

The overall risk of steel industry 1 was found high while other three industries had medium risk. High risk in steel industry 1 is due to poor housekeeping, lack of proper ventilation, lack of safety awareness, high dust level inside industry premises and lack of PPEs provided for workers. Steel industry 2, 3 and 4 had comparatively good housekeeping, safety awareness among workers, had displayed safety signage in the premises, availability of proper ventilation, machine guarding and barricading was done.

All of the visited industries need to minimize the risk in all of their sections. Based on the observation, hazard identification and risk analysis, recommendations for risk minimization for each industry have been provided.

## 4.2 Recommendations

Based on the study, following recommendations are provided to improve OSH of billet based rolling mills.

**Recommendations for Others**

***Government***

The Department of Labour and Occupational Safety should:

- Strictly monitor and supervise implementation status of Existing Labour Act in all rolling mills.
- Make a provision to submit their accident record annually to the Department of Labour and Occupational Safety (DoLOS).
- Amendment in existing law and make clause specific to the concern industries.
- Publish specific hazards Permissible Exposure Limits to the specific Industries.
- Make provision to submit annual OSH audit report to the DoLOS.

***Rolling Mills***

The modern preventive and control measures for improvement of occupational safety and health is based on the hierarchy.

- Elimination;
- Substitution;
- Engineering controls;
- Signage/warnings and/or administrative controls; and
- Personal protective equipment.

**Hazard Identification**

- Identify the all 6 types of hazards (Physical, Chemical, Mechanical, Biological, physiological and Psychosocial) existing in rolling mills and Assess the risk of that particular hazards to the workers.
- Compulsorily keep and display the Safety Data Sheet (SDS) all Chemicals in working area preferably in local language.
- Implementation of OSH Management System based on ISO 45001.

After the identification of hazards, risk assessment should be done. After risk level is assessed the hierarchy of the measure the management of the rolling mill should follow:

**Elimination/Substitution**

- Introduce melting and online casting system (self-manufacture of billet) instead of billet reheating furnace.

**Engineering Control**

- Identify and segregate the pressurised vessels. Restrict to melt in induction furnace.
- Timely replaced and repaired the induction furnace lining.
- Use robot system to operate the induction furnace.
- All dangerous parts of machinery and equipment, conveyors, long travel shafts and gearing on overhead cranes, should be securely guarded.
- An effective lockout/tag out program should be in operation for maintenance and repair.
- Lighting of all parts of the shops and machine guards should be of a high standard.
- Good general ventilation throughout the plant and local exhaust ventilation (LEV) wherever substantial quantities of dust and fumes are generated or gas may escape are necessary.
- Wherever possible, sources of noise should be isolated. Remote central panels remove some operatives from the noisy areas; hearing protection should be required in the worst areas.
- Moving parts of the automatic machines must be properly guarded and emergency stop buttons should be present to shut down the machines in emergency. Lockout/ Tag out procedures are required during maintenance of such machines.
- Install fire extinguisher at all work station.
- Make a provision in case of any accident as the load fluctuate, panel box trips automatically and electricity supply is disconnected to avoid hazards.

**Administrative/Training/Signage**

- Regular inspection, examination and maintenance is necessary for all machinery and equipment of the plant, particularly for cranes, lifting tackle, chains and hooks.
- Formulate safety policy and display in local language.
- Formulate and get function safety committee.
- Display safety signages and safety awareness postures.
- Introduce regular training on OSH and focused on information about hazards, safe methods of work, avoidance of risks and the wearing of PPE.
- Salt replacement is needed for jobs involving profuse sweating and is best achieved by increasing salt intake with regular meals.
- Pre-placement medical examinations are of great importance in selecting persons suitable for the arduous work in iron and steel making.
- A central first-aid station with the requisite medical equipment for emergency assistance should also be provided.
- Placement of mandatory, informative and warning signage to the workplace in pictorial and local language
- Provision of emergency exits and marked or defined.

**Personal Protective Equipment**

- The workers working at furnaces need clothing that protects against burns, overalls of fire-resisting material, spats, boots, gloves, helmets with face shields or goggles against flying sparks and also against glare.
- Safety boots, safety glasses and hard hats are imperative in almost all occupations and gloves are widely necessary.

## References

Department of Industry (DoI). 2021. Detail study of Thermo-Mechanically Treated (TMT) Bar Manufacturing Industry in Nepal.

ESPS/DANIDA. 2001. Cleaner Production Implementation in Industries Report.

International Labour Organization (ILO). 1992. Recent Developments in the Iron and Steel Industry. Report l. Geneva: ILO.

International Labour Organization (ILO). 2001. Guidelines on occupational safety and health management systems.

Nepal Law Commission. 2017. *Labour Act - 2017,* September.

Shankar. E., Suresh. Balaji. S. & Dheenathayalan. T. 2016. Hazard Identification and Safety Control in Hot Rolling Mill.

World Health Organization (WHO) Commission on Health. 1992. Report of the Panel on Industry and Health. Geneva: WHO.

# Annex

**List of Visited Industries**

1. Ashok Steel Industries Pvt. Ltd., Bara, Nepal
2. Jagadamba Enterprises Pvt. Ltd., Parsa, Nepal
3. Narayani Ispat Pvt. Ltd., Bara, Nepal
4. Sarbottam Steel Pvt. Ltd., Parsa, Nepal