ISSN 2395-1621

Design Procedure of Overhead Trolley system for Cooling of Cast Components

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ABSTRACT

Handling of raw material, semi finished, finished product and other material is ever concern and cost in an industry. With increasing cost of labour and its scarcity, the manual work or operation in industries are now replaced by semiautomatic or automatic system. These low cost systems are not only cost efficient but also enhance productivity and address the issues related to labour problem. Conventionally in micro or small scale industries which are labour intrinsic transportation of raw material, semi finished product is always an expensive and problematic issue. After visiting the industry and after discussion with the concern, the shifting of casted components from foundry to machining shop was a costly labour activity. Presently it is done manually. The industry was interested to identifying some optional material handling system to encounter their problems. After carefully survey of factory layout, discussing with management, concern exhaustively literature search it was preferred to design and develop an overhead Trolley conveyor for cooling of casted comonents. The main aims to design cost efficient, overhead Trolley conveyor system so that casted component could be conveyed from foundry to machining bay while it cools down on the conveyor.

Keywords: Overhead Trolley Conveyor, I-Beam Track, Chain, Trolley, H-Attachment, I-Attachment, Dead load factor, Operating wind load, Hoist load factor

ARTICLE INFO

Article History

Received: 30th April 2017

Received in revised form :

30th April 2017

Accepted: 3rd May 2017

Published online :

7th May 2017

I. INTRODUCTION

The purpose of this is to present a basic concept for the design of a single beam trolley system for overhead material handling. The concept and procedures were presented in a matter that it is useful for designing perfect Trolley conveyor for the industry with minimum capital investment and to obtain maximum output in term of money, time and quantity.

Basic principles of selecting material handling system

• Direction of load travel.
• Length of load travel.
• Properties and characteristics of the material being handled.

- The rate of flow of material.
- Kind of the production process.
- Method of loading and unloading.
- Existing layout and conditions of the work space.
- Initial and operational costs

Some important material handling system

- Trolley conveyor
- Belt Conveyor
- Screw Conveyor
- Slat Conveyor
- Deep Pan Conveyor
- Drag Chain Conveyor
- Rope way Trolley
- Skip Charging System

Overhead Trolley conveyors are primarily used to lift large or heavy items and move them horizontally. Trolleys can be driven manually or powered. Power-operated overhead Trolley systems are typically powered by air, hydraulics, or electricity.
Overhead material handling systems can be supported on single or multiple girders and can be top-running or bottom-running.
Bottom-running systems travel along the bottom flange of the supporting beam and are typically associated with monorails and bridge cranes. Multiple girders and top-running systems are typically not associated with Trolley but rather with overhead or gantry bridge cranes. This course covers the basic design of a monorail with a Top running manually driven on a single beam.

II. SELECTION OF CONVEYOR COMPONENTS

This subject is dealt with exhaustively in trade literature, and it is only proposed to mention the main points to be consider briefly.
It is then necessary to decide on the load, speed, idler type and structure in order to establish the basic parameters of the conveyor design.

I-Beam Track

The I beam Track must support the entire load carried by the conveyor and the lower flange of the I beam must be withstand the wear cause

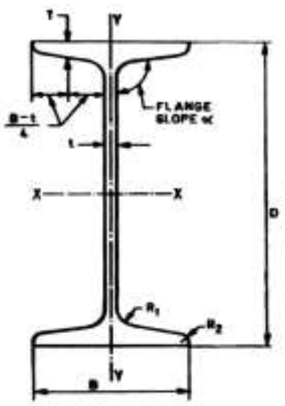

Fig. (i) Cross section of ISMB

Chain

To determine the proper size of the chain you need to analyze total pull in the system and required number of drives. I-beam Chain is drop forged and heat treated for added strength and resistance to corrosive to abrasive to weight reaction.

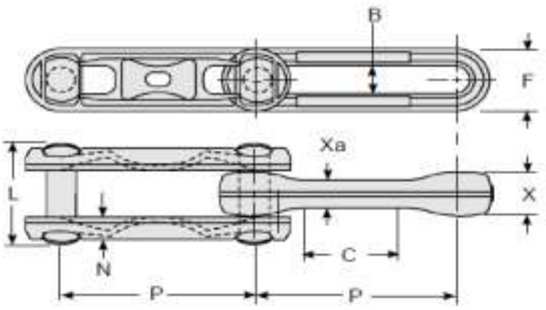

Fig. (ii)Rivetless Chain

I-Beam Trolley

The I-Beam trolley is design to use with the 3" to 4" I-Beam track. It is important element of a system which pull entire load hence it should withstand to the heavy stress and load factor.

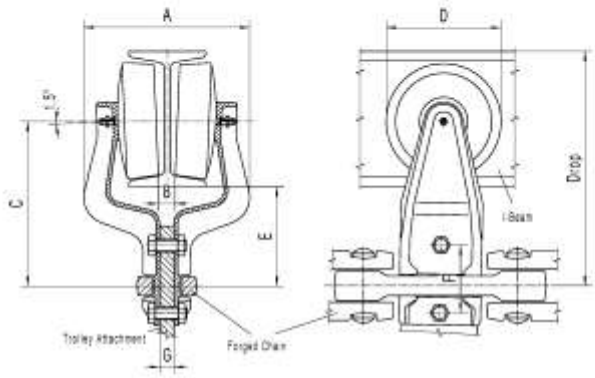

Fig. (iii) I- Beam, Trolley and Chain

Clevis "H" Attachment

The standard clevis H attachment is commonly used type trolley attachment. The H attachment is used with the both the 3" and 4" trolley. It consists of two pieces of formed steel which fit between the trolley halves.

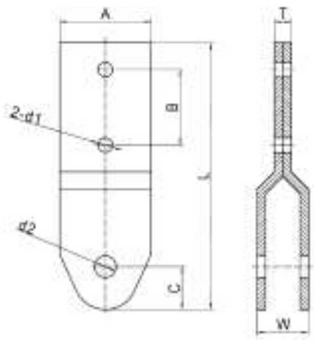

Fig. (iv) H- Attachment

I-Attachment

The "I" attachment is used with intermediate trolley that do not carry any load. "I" attachment used where loaded trolley exceed the maximum 36" for 3" I-Beam and 32" for 4" I-Beam.

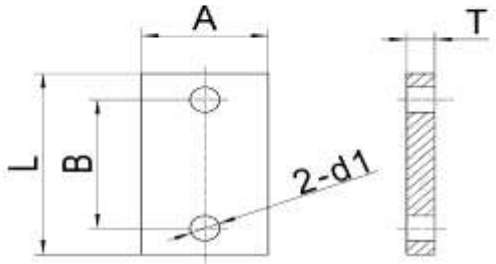

Fig. (v) I- Attachment

Roller Turn

The roller turn is used for carrying an overhead I-Beam Conveyor chain around the horizontal curve.

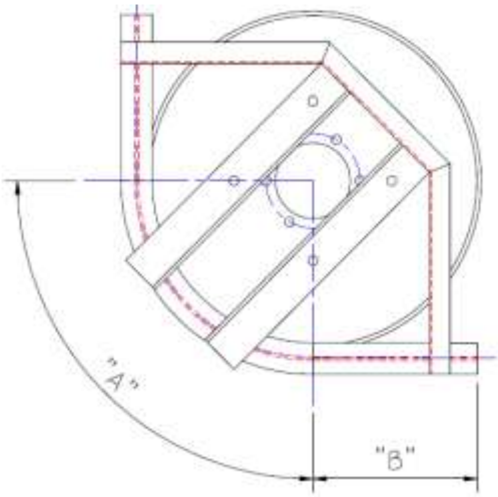

Fig. (vi) Roller turn

III.DESIGN CALCULATIONS AND PROCEDURES

Clearances

Dimensions of the largest and heaviest items to be lifted are required in order to assure that proper access is provided along the entire path of the monorail Conveyor Equipment Manufacturers Association (CEMA) provides minimum clearance requirements of 2 to 3 inches at different locations along the monorail. Use of larger clearances is recommended to account for any unknowns, deflection of other items or supporting structure in the area, and to allow for more flexibility during installation and future uses.

Support Locations

Support locations are determined based on (and not limited to) the following:

• Combined axial and bending stresses
• Fatigue allowable stress range
Deflection limitations

Maximum beam height allowed ñ the span may need to be shortened if a deeper beam cannot be used to reduce stresses or if deflections result in clearance problems. The design of the monorail beam along with the supports and connections can be an iterative process. However, the design of the supports is not within the scope of this course.

Connections

Bolted and/or welded connections can be used on a Track. The type of connection may be driven by the owner in the specification, costs, and constructability. The CEMA code provides guidance for the fatigue check of a welded connection. For bolted connections, AISC in ASD and LRFD list bolt capacities for strength checks, for fatigue of bolted connections.

Deflection Limitation

The most common shape utilized for the design of trolley with under hung hoists is the S-shape. The S-shape sections have narrow flange widths but also thicker flanges compared to equivalent W-shape sections.
Track can also be designed using W-shape sections; however, the local bending of the bottom flange due to the wheel loads governs the design of the beam more often.

ASTM A36 (Fy = 36 ksi) is the most common material readily available for S-shape sections. ASTM A992 (Fy = 50 ksi) is now more common for W-shape sections. Recently, ASTM revised the A992 specification to include shapes other than W-shape; however, S-shapes are not yet readily available in A992.

The loads as defined by the CMAA specification are as follows:
The I-beam should also be designed for in-line (axial) and out-of-plane (lateral) loading. AISC ASD states that a minimum of 10% of the load shall be applied in-line or longitudinally and a minimum of 20% of the load shall be applied normal to or perpendicular to the beam. The load used in the calculations should be based on the lift load and the trolley weight with all load factors applied. Torsional moment caused by the out of plane loading should also be accounted for in the design. The moment is determined by multiplying the lateral load by the vertical distance between the beams is shear center and the centerline of the load. The load is generally assumed to be applied at the bottom flange for bottom-running trolleys; therefore, for a standard S-beam or I-beam, the distance is one-half (1/2) the beam depth.
To determine the torsional stress on the beam, AISC's Steel Design Guide Series 9:
Torsional Analysis of Structure Steel Members can be referenced. The stresses are determined using the section modulus of one flange only.

Load Factors

Load factors are used to account for such items as impact and dynamic lift situations, or to account for unknowns. The load factors discussed below are as defined by the CMAA code; however, these factors can be adjusted to account for the specific design situation being investigated.

Dead Load (DL): The weight of the monorail beam and any other fixed item supported by the beam.

Trolley Load (TL): The weight of the trolley and any other equipment attached to the trolley.

Lifted Load (LL): The weight of the item lifted along with all associated lift devices such as slings, shackles, spreader beams, etc.

Collision Forces (CF): Loading resulting from the collision with another trolley or bumper stop. The velocity and mass of the objects are required to determine the kinetic energy released during the collision.

Inertia Forces from Drives (IFD): Forces occurring during the acceleration, deceleration, and motions of the monorail.

Operating Wind Load (WLO): The loading on the projected area exposed to the wind. The wind velocity at which a safe lift should be used is specified by the owner. The code states that a minimum of 5 psf loading should be used if no information is provided.

Stored Wind Load (WLS): The maximum wind applied to the monorail when the system
is not in use.

Forces Due to Skewing (SK): Horizontal forces normal to the beam when wheels roll along the length of the beam. A table provided in the code is used to determine a factor to be applied to the wheel loads.

Dead Load Factor (DLF): This factor covers the dead loads of the trolley hoist and any associated equipment. The factor is based on the travel speed of the trolley and is determined using Equation

$$DLF = 1.01 < 1.05 + (\textit{Travel Speed}/2000) < 1.20 \quad \ldots(1)$$

Where, *Travel Speed* is in feet per minute (fpm).

For a powered trolley, the minimum dead load factor is 1.10. For a trolley that is manually-driven, the travel speed is relatively low so Equation (1) is not required. A factor of 1.05 to 1.10 should be utilized to account for some unknowns such as mill and weld tolerance.
Note that the Dead Load Factor (DLF) accounts for the dead load of the beam (DL), trolley and associated equipment (TL), while the term Dead Load (DL) introduced in the previous section only refers to the dead load of the beam. It is important to note this distinction since the nomenclature can be somewhat confusing.

Hoist Load Factor (HLF): This factor accounts for the motion of the rated load in the vertical direction. The factor also accounts for inertia and mass forces due to sudden impact load during lifting. The factor is also a catchall accounting for all other uncertainties. The HLF factor is determined using Equation (2).

$$HLF = 1.15 < 1 + 0.55 \text{ X } \textit{Hoist Speed} < 1.50 \quad \ldots(2)$$

Where, Hoist Speed is in feet per minute (fpm).

For manually-driven trolleys, the load is typically hoisted without the use of power thereby the hoist speed is relatively low. Therefore,
Equation (2) may be ignored and a minimum factor of 1.10 to 1.15 can be used.

Load Combinations
The CMAA specification requires that combined stresses be checked for three different stress levels. The three (3) load combinations requiring evaluation are:

Case 1: Monorail in regular use under principle loading (Stress Level 1).

$$(DL \times DLF) + (TL \times DLF) + (LL \times HLF) + IFD \quad \ldots(3)$$

Case 2: Monorail in regular use under principle loading additional loading (Stress Level 2).

$$(DL \times DLF) + (TL \times DLF) + (LL \times HLF) + IFD + WLO + SK \quad \ldots(4)$$

Case 3: Monorail under extraordinary loading
(Stress Level 3). There are two conditions evaluated for this case. Monorail not in use and Stored Wind Load

$$DL + TL + WLS \quad \ldots(5)$$

IV. CONCLUSION

After brief study and experimentation we concluded that Overhead Trolley conveyor is best suitable conveyor for the Industry as per application, economical, maintenance, space availability point of view.

ACKNOWLEDGEMENT

The authors are thankful to Professor J. M. Patil for his valuable suggestions in this study.

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