THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XIV MECHANICHAL ENGINEERING, ISSN 1224-5615
2025

ASPECTS RELATED TO CONCEPT, DESIGN DEVELOPMENT, AND OPERATION OF DRAWING BRIGE

Assoc. prof. Gina Diana MUSCA
Master's student Eng. Irina ROSU LUCA
"Dunarea de Jos" University of Galati, Romania, Faculty of Engineering and Agronomy in Braila, Research Centre for Machines and Technological Equipment's Mechanics

ABSTRACT

In the design and construction of overhead cranes, the choice of equipment supplier plays an essential role. Overhead cranes are widely used in industry for handling heavy loads, and knowledge of manufacturers is important for selecting the optimal solutions from a technical and economic point of view. In almost any industrial field, overhead cranes are indispensable solutions for handling heavy, bulky, or difficult-to-maneuver loads. Their use in the classic suspended systems variant for handling loads offers the main advantage of creating a large space at ground level for transport functions.

KEYWORDS: crane, mechanical transmissions, bridges

1. INTRODUCTION

The overhead crane is a type of mobile crane consisting of a horizontal metal structure, equipped with wheels at the ends, which moves on parallel rails mounted at a height. Overhead cranes are used for handling goods in confined spaces. (such as industrial halls, warehouses, or power plants), but also outdoors. They can transport bulky or heavy loads, such as metal parts, building structures, containers with granular materials, containers with molten metal, foundry molds, or prefabricated concrete elements. Overhead bridges have the particularity of performing all working movements through perpendicular reciprocal translations, so that, in general, the load suspension device has access to any point of a parallelepiped action field. The possible movements are: lifting-lowering the load, translation of the load trolley, and translation of the entire crane. All these movements are designed as working movements. During handling and transportation, the load performs exclusively translational movements. In combination with other handling equipment, overhead travelling cranes can cover the entire surface of a defined work area, facilitating complex handling, storage, and assembly operations, as well as automated integration between stages of the production process [1]. Overhead travelling cranes are generally constructed with either a single or two main girders. Those with a single main girder are called rolling girders or single-girder bridges, and those with two main girders are called double-girder rolling bridges.

There are several construction variants of rolling bridges:

a) Single-girder overhead bridges built in 3 variants:

- single-girder overhead bridge with the main beam made of laminated profile (fig. 1);
- single-girder overhead bridge with the main beam made of welded caisson profile (fig. 2);
- suspended overhead bridge fig. 3).



Figure 1. Single-girder overhead bridge with main beam made of laminated profile



Figure 2. Single-girder overhead bridge with main beam made of laminated profile



Figure 3. Single-girder suspended overhead bridge

b) Double-girder overhead bridges built in 2 variants are:
- double-girder overhead bridge, main beams made of laminated profile (fig. 4 - a);
- double-girder overhead bridge, main beams made of welded caisson profile (fig. 4 - b).





a) b)

Fig. 4. Overhead bridges
a) double-girder overhead bridge, main beams made of laminated profile
b) double-girder overhead bridge, main beams made of welded box section

2. DESIGN OF OVERHEAD BRIDGES

Overhead cranes integrate standard components such as assembly elements, mechanical transmissions, bearings, and couplings.

Their structure includes a mobile metal frame that moves along fixed rails mounted on the infrastructure.

The load handling system is provided by a mobile trolley, equipped with gripping devices that can move along the bridge girder (fig. 5).

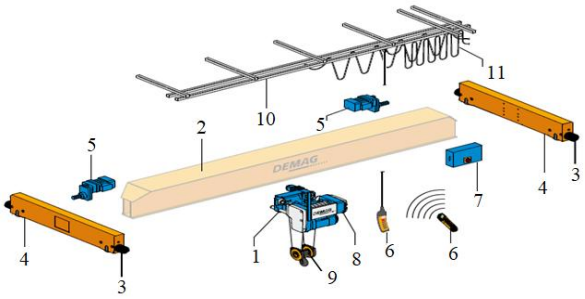

Figure 5. The components of the overhead crane
1 - load hoist trolley; 2 - main beam; 3 - buffers; 4 - end beam; 5 - bridge travel motor; 6 - radio remote control; 7 - electrical equipment; 8 - cable drum; 9 - hook muff; 10 - cable trolley chassis; 11 - power supply cable.

3. DESIGN OF OVERHEAD BRIDGES

The design of a crane bridge requires a complex analysis to ensure structural stability, operational safety, and compliance with European standards.

Main design phases and associated costs:

a) Preliminary studies and feasibility analysis (€5,000 – €15,000)
- Evaluation of customer needs (lifting capacity, opening, frequency of use);
- Analysis of site conditions (hall height, permissible overloads).

b) 3D design and strength calculation (€10,000 – €30,000)
- Parametric modeling in AutoCAD Inventor or SolidWorks;
- FEM (Finite Element Method) simulations to check the stresses in the beam;
- Dynamic calculation of oscillations during the movement of the bridge.

c) Technical documentation and permits (€2,000 – €8,000)
- Development of the use and maintenance manual;
- Obtaining ISCIR approvals and environmental permits.

The working equipment of the overhead crane is represented by the load trolley on the chassis of which the electric hoist and the trolley movement mechanism are mounted [4], [7].

The load trolley is an assembly designed to move with the suspended load, which runs on the rails on the metal construction of the bridge. The trolley chassis is a metal construction whose structure is obtained by welding. The elements of the steel structure of the chassis that support the mechanical or electrical

equipment of the drives are provided with contour-welded additions. They have appropriate thicknesses to be processed on the seating surfaces. The trolley chassis is provided with stops that ensure that it will not fall off the trolley rails even if the supporting shaft of a running wheel breaks.

In addition to general-purpose machine parts (shafts, bearings, springs, assembly parts, or parts for transmitting movements), overhead crane trolleys have a number of parts that are specific to these machines.

The hoist represents the assembly of fixed and mobile rollers alternately wound by the flexible traction member. It is the specific element of lifting and transporting machines serving to amplify the driving forces, and can also be used as an independent mechanism for lifting loads. The cable hoist can be:

a) simple (fig. 6 a) when one end of the cable is fixed to the drum, the other end of the flexible traction member being fixed to one of the pulley bodies of the hoist;

b) double (twin), when both ends of the flexible traction member are wound on the drum (fig. 6. b).

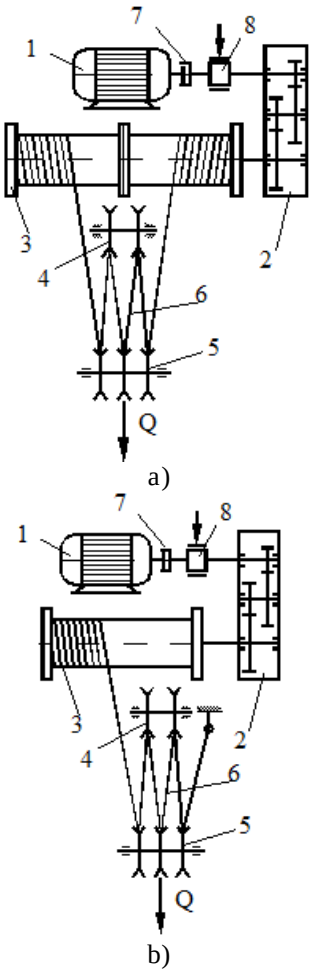

Fig. 6. Lifting mechanism of the overhead crane

a) Double hoist lifting mechanism

b) Lifting mechanism with simple hoist

1 - electric motor; 2 - reducer;

3 - drum; 4 - rollers; 5 - coupling with hook;

6 - cable; 7 - coupling; 8 - brake

The lifting mechanism is a driven mechanism for raising and lowering the rated load. The lifting coupling is used to couple the output shaft of the reducer with the lifting drum and is mainly composed of a coupling flange, hub, barrel rollers, and covers.

The hoisting drum is supported on the reducer side by the hoisting coupling and on the other side by the hoisting bearing, with the stroke limiter. The drum grooves are turned, the surface roughness having the necessary quality to contribute to reducing the wear of the hoisting rope. The coupling assembly is of the short-shank hook type. The hook is assembled with the coupling shields below the cable pulley shaft. The coupling of the auxiliary lifting mechanism is provided with two cable pulleys [3].

The hook, together with its crossbar, is mounted on both sides using robust protective shields. The roller shaft is fitted with a spacer bushing to maintain a fixed height between the two shields. As the cable rollers have their bearings mounted on the bushings, the entire assembly is fixed to the roller shaft by means of caps, which are fitted at each end of the shaft.

The metal construction of the overhead crane consists of:

Main beams (fig. 7) – in a narrow caisson system consisting of cores and soles welded together and stiffened by transverse frames and longitudinal stiffeners. Above the inner core on the upper sole is the running track of the load trolley. The main beams are joined to the end beams by welding.



Fig. 7. Main beam

End beams (fig. 8) – in a caisson system consisting of cores and soles welded together. The beams are stiffened with transverse diaphragms. The end beams are made of two articulated pieces, which rest on two wheels each.



Fig. 8. End beam

There are two travel mechanisms, namely: the trolley travel mechanism and the overhead crane travel mechanism [5].

The trolley travel mechanism

The trolley travel mechanism is an assembly in which the drive group (with a gearbox in a closed housing) is located between the driven wheels, having shafts for moving the trolley.

The shafts (equipped with universal compensating couplings) are installed to compensate for the deflection produced by the crane loads and the angular deviations caused by the trolley chassis.

Properly selected buffers reduce the shock loads that can be transmitted to the metal structure of the crane.

The buffers are mounted on the trolley. The system is equipped with stops to control the trolley movement.

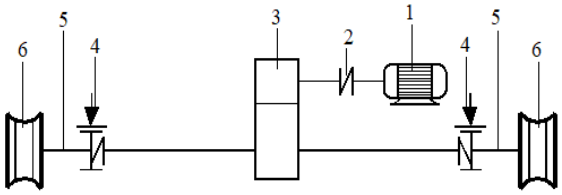

Fig. 9. Overhead crane trolley travel mechanism

1 - electric motor; 2 - coupling; 3 - reducer; 4 - brake; 5 - axles; 6 - running wheels

Travel mechanism of the overhead crane

The travel mechanism is intended to ensure the translational movement of the overhead crane. The electric motor is coupled with a reducer (which has gears with inclined teeth).

The output shaft of the reducer is directly connected to the shaft of the driven running wheel through appropriate couplings. Appropriately chosen buffers are mounted at each end of the two end beams.

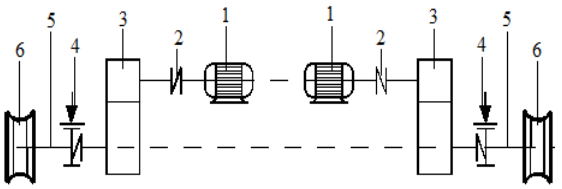

Fig. 10. Overhead crane travel mechanism. Independent motor drive

1 - electric motor; 2 - coupling; 3 - reducer; 4 - brake; 5 - axles; 6 - running wheels

The running wheels are designed as assemblies containing both the running wheel and the bearings on both sides of the wheel.

The wheel assemblies with bearings and guide lips are used in two variants: driven and non-driven.

Elastic couplings with bolts and brake drums are used to connect the electric motor shaft to the input shaft of the gearbox and consist mainly of a flanged half-coupling and a half-coupling with brake drums.

Elastic couplings with bolts and brake drums, as well as double-shoe brakes, are used in all crane drives.

The brake is opened by the action of the electro-hydraulic lifter, which is mounted at one end of the brake support.

Each mechanism of the overhead crane is equipped with drum brakes, using a two-shoe system.

The two-shoe brakes are used to stop the trolley moving with the nominal load and to be able to safely stop the movement of the overhead crane.

All overhead crane brakes are for stopping movements, and their function is to ensure the deceleration to a stop of the mechanisms, which are provided with drives via rotary shafts.



Fig. 11. Hydraulic lift brake mechanism

The safety components have the role of ensuring the operation of lifting installations without the risk of damage and accidents.

They must intervene when incorrect maneuvers are performed or in the event of certain defects that present danger.

By activating the safety devices, the movement of the crane that has been incorrectly performed must be interrupted, or in the event

of a defect, the equipment must be kept safe and out of danger.

The main safety devices mounted on overhead cranes are: End-of-travel limiters, Load limiters, Stoppers and buffers, Support parts and rail cleaners and Hook fuses.

Other safety components: electrical contacts, emergency button, acoustic and optical signals, etc.



Fig. 12. Stroke limiters

Electrical installation

The DCL track is easy to install thanks to the new connection principle, and simple to attach to the ceiling and metal structures. It is designed for currents up to 200 A and can be equipped with 7 conductors.

All mechanisms are driven by three-phase asynchronous motors, powered at a nominal voltage of 380V and a frequency of 50Hz.



Fig. 13. Electric motors

The movements are controlled from the control block, which can be connected locally via a control cable or can be operated via radio or infrared.

4. DEVELOPMENT AND OPERATION OF OVERHEAD BRIDGES

The development and operation of overhead cranes is a critical area in modern industry, aiming both to streamline lifting and transport processes and to ensure maximum operational safety [2].

The development of overhead cranes involves: automation, technical innovation, adaptation to high loads, energy efficiency, functional safety, and last but not least, innovation.

The operation of overhead cranes involves: training personnel, compliance with safety regulations and ensuring maintenance [6].

The main parameters of the operating conditions are:

The working area of the overhead cranes is a parallelepipedal field of action. The possible movements are: lifting-lowering the load, translation of the load trolley, and translation of the entire crane. All these movements are designed as working movements.

The duration factor of the working regime is expressed by the formula:

$$D_a = \frac{\sum t_{ef}}{\tau} \cdot 100, \qquad (1)$$

Where the numerator represents the sum of the effective working times, and T is the duration of a cycle, which conventionally does not exceed 10 minutes.

The duration of a cycle is the sum of the actual working times and the break times.

The relative workload, defined by the relationship:

$$S_R = \frac{\sum n_i \cdot Q_i}{n \cdot Q} \cdot 100, \qquad (2)$$

where: n_i n - number of strokes performed with load Q_i; n - total number of strokes it Q - nominal load.

The use class of a lifting machine is determined by the average daily operating time expected for it, expressed in hours (Table 1).

Table 1. Usage classes of lifting machines

Class of use	Average daily operating time, hours	Total service time, hours	Observations
T0	≤ 0.125	200	Occasional use
T1	0.125-0.25	400	Occasional use
T2	0.25-0.5	800	Occasional use
T3	0.5-1	1600	Occasional use
T4	1-2	3200	Light duty use
T5	2-4	6300	Intermittent use
T6	4-8	12000	Medium use
T7	8-16	25000	Heavy use
T8	≥16	50000	Heavy use
T9	≥16	Over 50000	Heavy use

The state of stress specifies the extent to which the lifting machine is subjected to maximum stress (due to the nominal load) and to lower stress (due to low loads). From the point of view of stress, lifting machines are divided into three groups (Table 2):
L1 lifting machines that are only exceptionally subjected to maximum stress but are currently being subjected to lower stress;
L2 designates lifting machines that operate with comparable service lives at both light and medium loads and at maximum capacity and
L3 refers to lifting machines permanently subjected to stress close to their maximum operating capacity.

Table 2. Operating groups of lifting machines

Request status	**Class of use**									
	T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
	Operating group									
L1	M1	M1	M1	M2	M3	M4	M5	M6	M7	M8
L2	M1	M1	M2	M3	M4	M5	M6	M7	M8	M8
L3	M1	M2	M3	M4	M5	M6	M7	M8	M8	M8

5. CONCLUSIONS

Overhead cranes are used in various operating conditions, which leads to a large variation, from one specific case to another, including the effective operating time and the loading state of the mechanisms or the metal construction. Thus, in order to design a product that is as cheap as possible, but at the same time as safe as possible while being operated, it is essential to have from the initial design phases as much data as possible about the operating conditions for each mechanism, in particular, about the nature of the demands to which different assemblies or subassemblies of overhead cranes are subjected.

Given that damage to overhead cranes entails serious dangers (in the event of a failure for some reason, the lifted load collapses and, in addition to its damage, human casualties may occur), all their mechanisms, as well as the metal structures of the frames or skeletons, must be made of quality materials that meet all technical requirements and are chosen according to the certificates of the factories supplying the materials and semi-finished metal products.

REFERENCES

[1] **Alămoreanu, M., Coman, L., Nicolescu, Ş.**, *Lifting machines, Vol. 1, Technical Publishing House, Bucharest, 1996* ISBN 973-31-0827-8.
[2] **Blesneag V., Muscă G. D.,** *Modernization of double-girder overhead crane 5 t x 24,1 m,* Buletinul AGIR An XXVI, nr.3/2021.
[3] **Muscă, G., D.,** *Lifting and transport machines – Course Notes*, Part I, Galaţi University Press Publishing House, ISBN 978 - 606-696-191-2, ISBN 978-606-696-192-9, 2020.
[4] **Muscă, G., D.,** *Lifting and transport machines – Course Notes*, Part I, Galaţi University Press Publishing House, ISBN 978 - 606-696-191-2, ISBN 978-606-696-192-9, 2020.
[5] **Oproescu, G.**, *Machines and installations for industrial transport, Edmunt Publishing House, 2001, Brăila*.
[6] **Oproescu, Ghe., Anghelache, G. D.,** *Elements of dynamics of lifting and transporting machines*, Galati University Press 2009.
[7] **Potîrniche, A., Căpățână, G., Muscă (Anghelache), D.,** *Considerations ongeometric modeling and finite element analysis for a trolly travel mechanism of an overhead crane*, ModTech 2021, IOP Conference Series: Materials Science and Engineering, Volume: 1182, Article Number: 012064, Published: 2021, doi:10.1088/1757-899X/1182/1/012064, 2021.