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GRAPHICAL MODELING OF A BAND BRAKE ASSEMBLY WITH A PNEUMATIC CYLINDER

Abstract: *3D modelling has an important role in the design and manufacture of complex mechanical components, such as band brake systems, which are actuated by a pneumatic cylinder. This type of brake is commonly used in various industrial applications due to its efficiency in transmitting braking force and long-term reliability. By using modeling software such as Autodesk Inventor, designers can create detailed models of components and assemblies, allowing for accurate fit and function verification prior to actual manufacturing. This approach reduces the risk of design errors and ensures a final product optimized for performance and durability. This paper presents the graphic modeling process of a band brake system, actuated by a pneumatic cylinder, emphasizing the importance of using modern technologies in the industrial field.*

Key words: *pneumatic cylinder, graphical modelling, Autodesk Inventor, band brake*.

1. INTRODUCTION

Band brake systems actuated by pneumatic cylinders have become a widespread solution in industry due to their reliability and efficiency in various applications, from heavy machinery to transportation equipment, Figure 1. These systems use the principle of friction to control and stop movement an object or mechanism in motion. A rotating drum is surrounded by a belt, usually equipped with friction material, such as ferrod, which is tightened by means of a pneumatic cylinder, generating the force necessary to stop the drum [1], [2], [3].

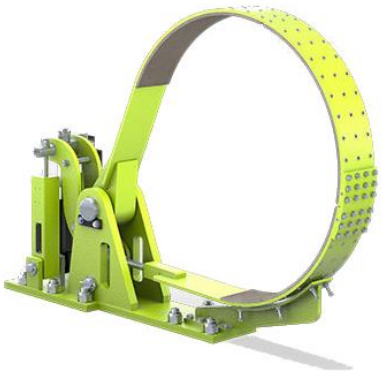

Figure 1 Band braking system [4].

Pneumatic actuation is an effective method of controlling these braking systems, as pneumatics allow for quick response and high precision in force transmission, while maintaining smooth and uniform operation. Another major advantage of pneumatic actuation is that it is relatively easy to integrate into complex systems, due to low maintenance costs and the robustness of the components [5].

Within a band brake system, the pneumatic cylinder plays a critical role, generating the force necessary to tension the band around the drum. This produces enough friction to reduce the speed or completely stop the movement of the drum [3], [6].

Band brakes are valued for their ability to provide significant braking force in a compact space and with a relatively simple setup. In addition, due to the use of pneumatics, the brakes are able to handle a wide range of loads and stresses, making them suitable for large industrial applications such as cable transport, cranes or lifting systems. Band brakes, especially pneumatically actuated ones, are preferred in industrial applications due to their simplicity of construction, low maintenance costs, and their versatility [7], [8].

In modern design, the use of 3D graphical modeling has become an essential step in the creation and optimization of complex mechanical systems, including band brakes. CAD (Computer-Aided Design) technology allows engineers to create detailed models of each component, simulate their operation and check possible interferences or deficiencies from the design phase, thus reducing the risk of errors and optimizing the performance of the final system [9], [10], [11].

A relevant example is the use of *Autodesk Inventor* software, a modeling program that provides a versatile platform for the design and analysis of mechanical components. This program allows the creation of a detailed assembly of the brake system, including each individual part, from the friction band and drum to the pneumatic cylinder and its supports. 3D modeling facilitates the simulation of braking system behavior under various operating conditions, providing a clear picture of how the com ponents interact and allowing them to be adjusted to optimize performance and durability [12], [13], [14], [15].

Thus, pneumatically actuated band brake systems continue to be a reference solution in the industrial field due to their efficiency, simplicity and ability to handle complex loads. Graphical modeling plays an important role in the optimization of these systems, facilitating correct and performant design, eliminating risks related to human error and increasing the durability of the finished product.

2. GRAPHICAL MODELING OF THE ASSEMBLY

The graphical part involves the 3D modeling of each component that forms the braking system assembly by means of *Autodesk Inventor* program. The execution drawings were made using the same software program, *Autodesk Inventor* allowing sketches to be generated from the 3D model of each part. Afterwards, each 3D-made component was assembled in **.iam* module of the design program, finally obtaining the three-dimensional model of the brake system. The brake system assembly consists of 31 parts and subassemblies.

In order to create the first assembly, named ”*Safety ring assembly*”, shown in Figures 2 and 3, the *Extrude* and *Hole* commands were used.

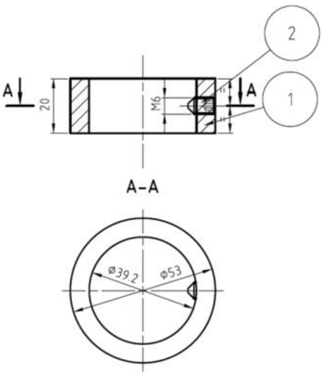

Figure 2 2D representation of the safety ring assembly: 1 - ring; 2 - fixing screw M6x10.

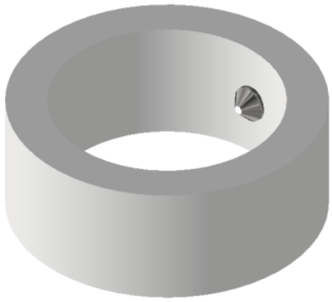

Figure 3 Safety ring assembly - 3D model.

The part represented in Figures 4 and 5, called ”*Joint*” was created using the 3D modeling commands: *Extrude*, *Hole* and *Thread*.

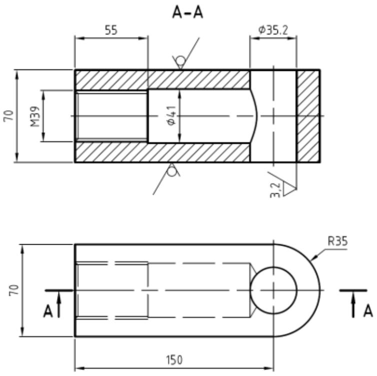

Figure 4 Joint - 2D model.

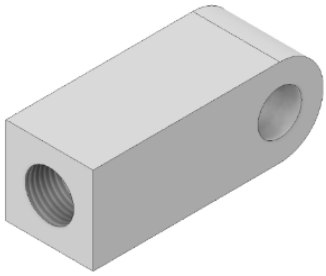

Figure 5 Joint - 3D model.

The part represented in Figures 6 and 7, called ”*Plate 1*”, was created using *Extrude*, *Chamfer* and *Hole* commands.

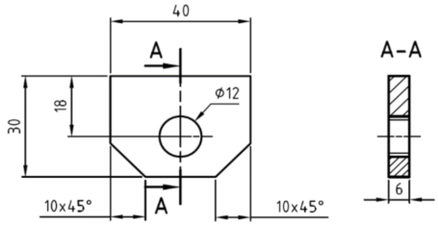

Figure 6 Plate 1 - 2D model.

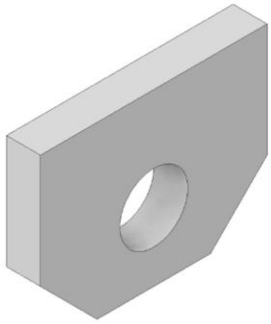

Figure 7 Plate 1 - 3D model.

Figures 8 and 9 show the ”*Plate 2*” part, which was created using *Extrude* and *Hole* commands.

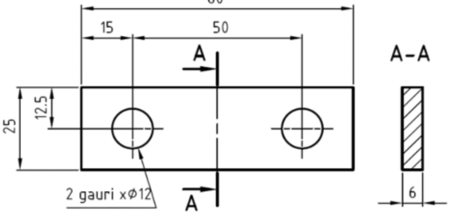

Figure 8 Plate 2 - 2D model.

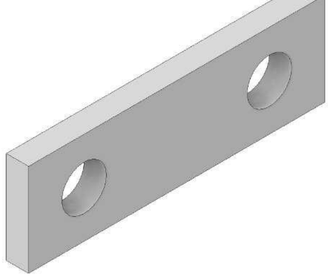

Figure 9 Plate 2 - 3D model.

Assembly 2, named ”*Strip stopper*”, shown in Figures 10 and 11, was created by joining two plates together. The *Extrude*, *Hole*, *Fillet* and *Thread* commands were used to create the plates.

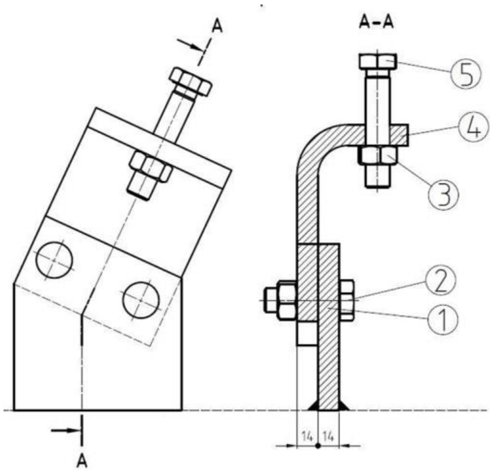

Figure 10 2D representation of the strip stopper assembly: 1, 4 - plates; 2, 5 - screws M16x50; 3 - hexagonal nut M16.

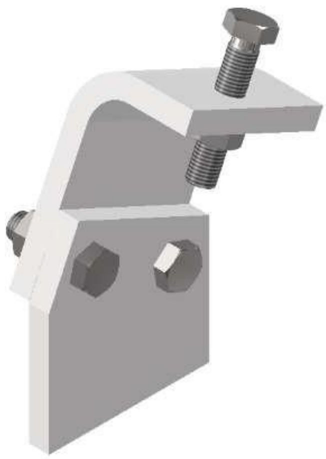

Figure 11 Strip stop assembly - 3D model.

Figures 12 and 13 show the two plates that forms the assembly 2.

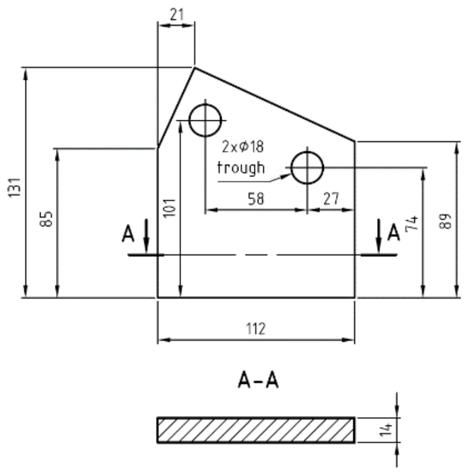

Figure 12 Plate 1 strip stopper - 2D representation.

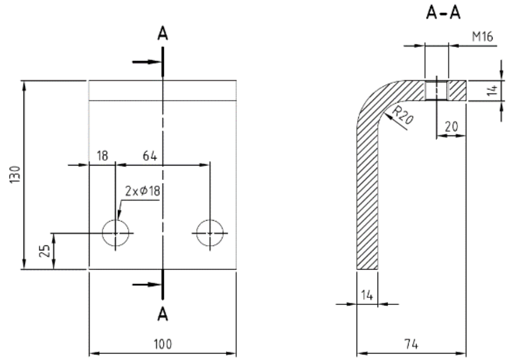

Figure 13 Plate 2 strip stopper - 2D representation.

”*Joint 2*” part, shown in Figures 14 and 15, serves as a connection element. The *Extrude*, *Hole*, *Chamfer* and Thread commands were used in order to create this part.

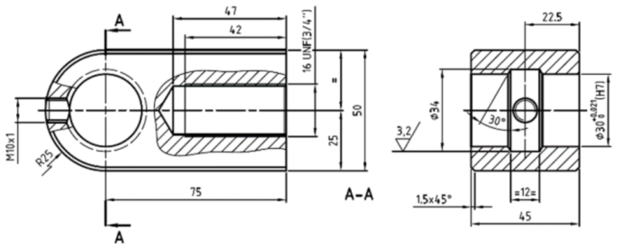

Figure 14 Joint 2 - 2D model.

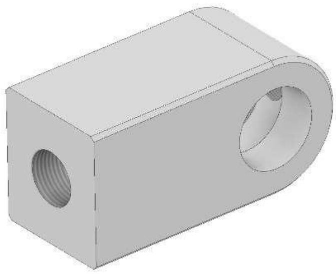

Figure 15 Joint 2 - 3D model.

The assembly named ”*Brake assembly*” shown in Figures 16 and 17, was made by connecting 4 types of plates with welding elements. The *Extrude*, *Chamfer*, *Hole*, *Fillet* and *Thread* commands were used to create the plates.

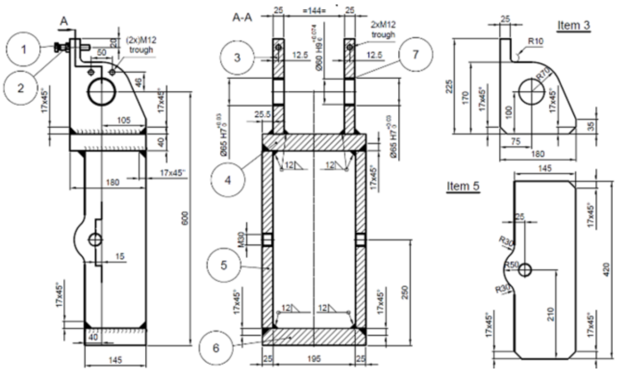

Figure 16 2D representation of the brake assembly: 1 - screw M12x75; 2 - M12 nut; 3 - plate 5; 4 - plate 6; 5 - plate 7; 6 - plate 8; 7 - self-lubricating ring Ø65xØ60xØ25.

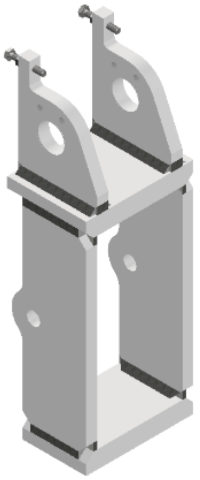

Figure 17 Brake assembly - 3D model.

The connection element called ”*Bolt 1*”, shown in Figures 18 and 19, was made using *Extrude*, *Chamfer*, *Thread* and *Cut* commands.

Also, in order to create the ”*Bolt 2*” element, shown in Figures 20 and 21, the commands *Extrude*, *Chamfer*, *Hole* and *Thread* were used.

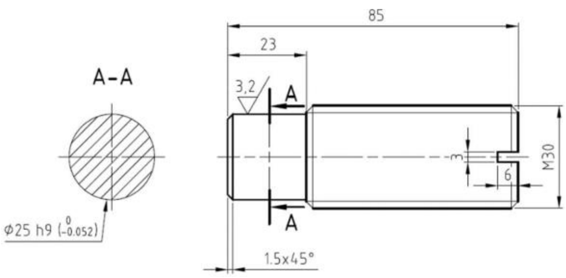

Figure 18 Bolt 1 - 2D model.

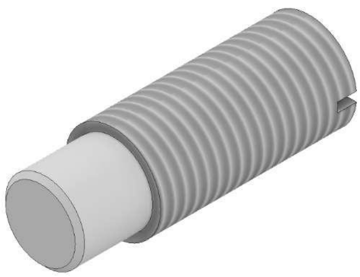

Figure 19 Bolt 1 - 3D model.

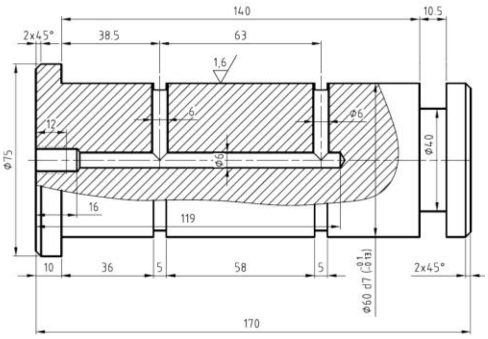

Figure 20 Bolt 2 - 2D model.

Figure 21 Bolt 2 - 3D model.

In Figures 22 and 23 ”*Bolt 3*” is presented, the *Extrude*, *Fillet* and *Thread* commands being used in the modeling process.

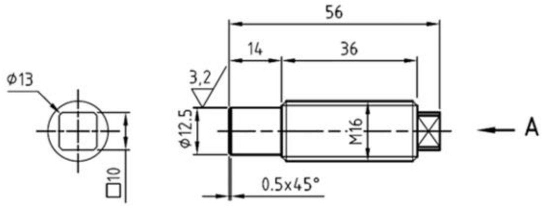

Figure 22 Bolt 3 - 2D model.

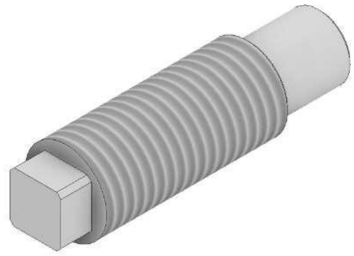

Figure 23 Bolt 3 - 3D model.

The parts called ”*Bolt 4*” and ”*Bolt 5*”, shown in Figures 24÷27, were created by using *Extrude* and *Chamfer* commands.

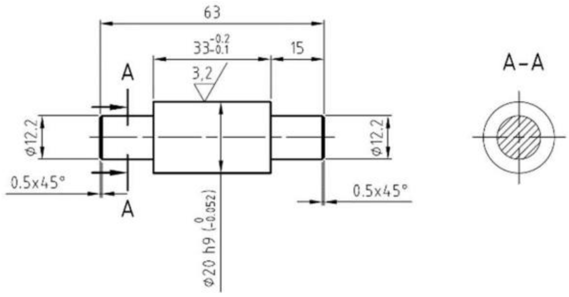

Figure 24 Bolt 4 - 2D model.

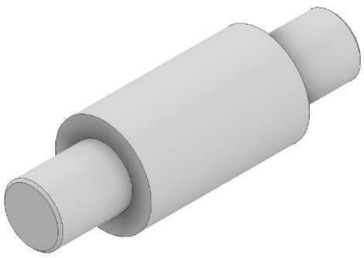

Figure 25 Bolt 4 - 3D model.

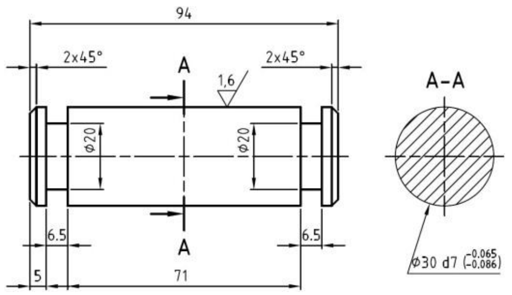

Figure 26 Bolt 5 - 2D model.

Figure 27 Bolt 5 - 3D model.

In order to create the part called ”*Connecting part*”, three views of it were created in 2D format, for a better understanding of the geometry of the part.

Therefore, *Extrude*, *Thread*, *Hole* and *Chamfer* commands were used in order to create this part. 2D and 3D representations of the part are shown in Figures 28 and 29.

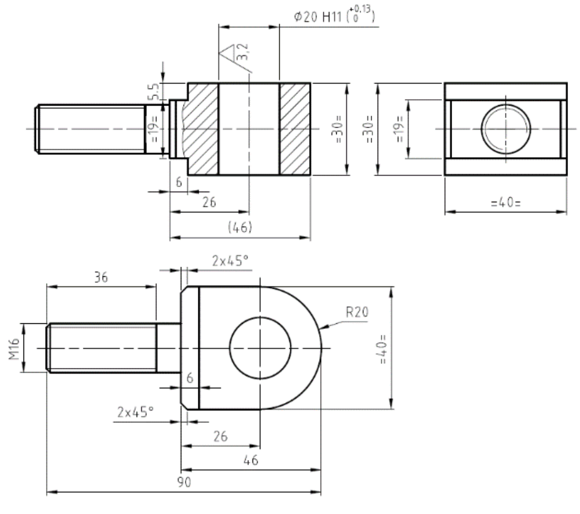

Figure 28 Connecting part - 2D model.

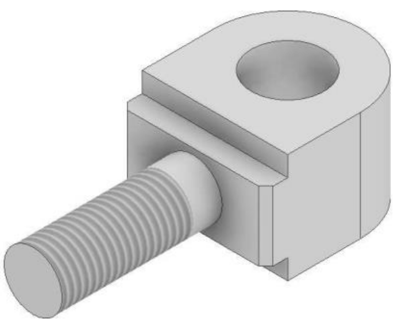

Figure 29 Connecting part - 3D model.

The next assembly shown in Figures 30 and 31, consists of a retaining ring and two screws. The bolts were inserted from *Autodesk Inventor* library and the retaining ring was created using *Extrude*, *Chamfer*, and *Hole* commands.

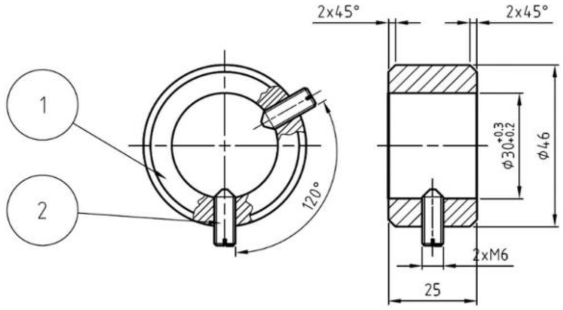

Figure 30 2D representation of the retaining ring assembly: 1 - ring; 2 - fixing screw M6x14.

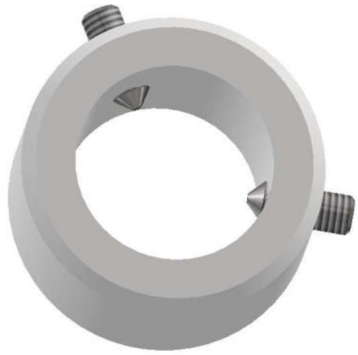

Figure 31 Retaining ring assembly - 3D model.

The assembly shown in Figures 32 and 33, called the ”*Ear assembly*”, serves as a connecting element obtained by welding one plate between two other identical plates. The following commands were used to create the parts: *Extrude*, *Hole* and *Thread*.

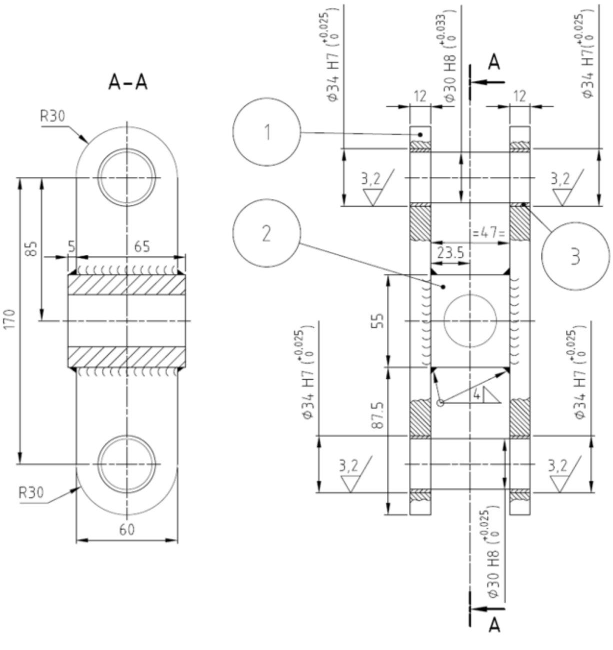

Figure 32 2D representation of the ear assembly: 1, 2 - plates; 3 - bush.

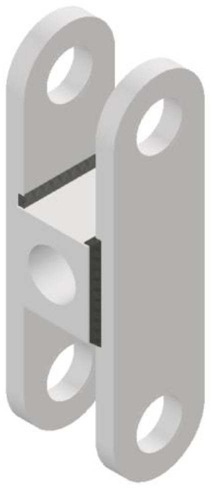

Figure 33 Ear assembly - 3D model.

Figures 34÷43 show ”*Bolt 6÷10*” parts. The *Extrude*, *Chamfer*, *Hole* and *Thread* commands were used in their modeling process.

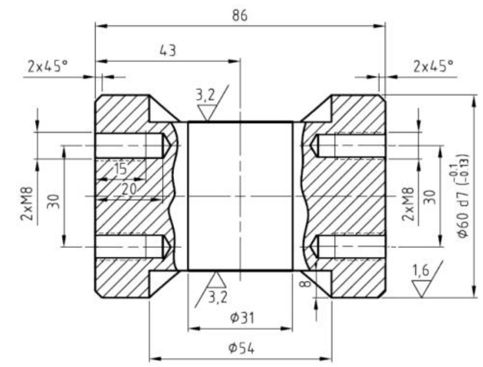

Figure 34 Bolt 6 - 2D model.

Figure 35 Bolt 6 - 3D model.

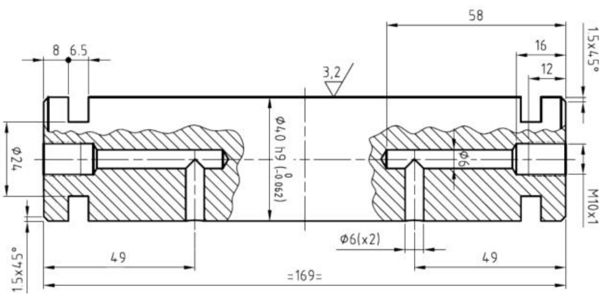

Figure 36 Bolt 7 - 2D model.

Figure 37 Bolt 7 - 3D model.

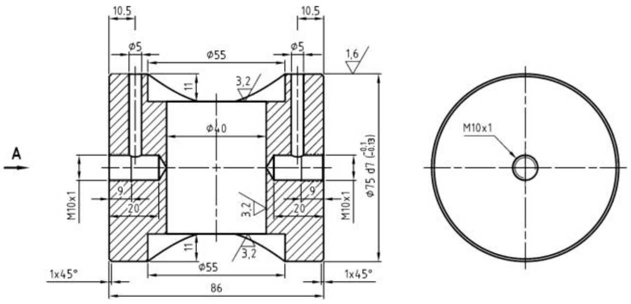

Figure 38 Bolt 8 - 2D model.

Figure 39 Bolt 8 - 3D model.

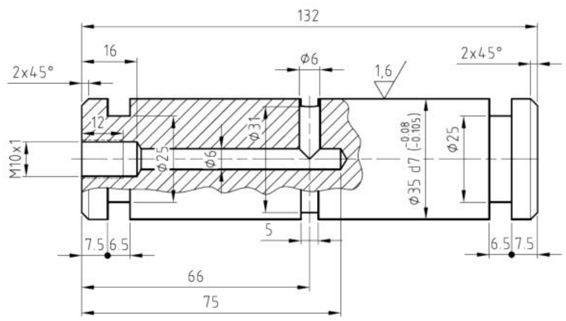

Figure 40 Bolt 9 - 2D model.

Figure 41 Bolt 9 - 3D model.

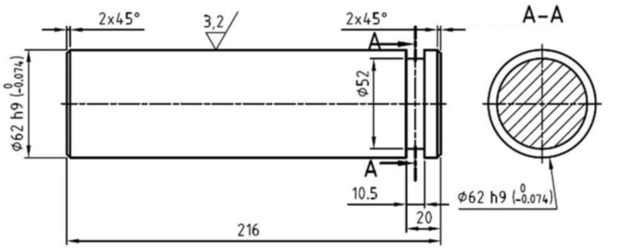

Figure 42 Bolt 10 - 2D model.

Figure 43 Bolt 10 - 3D model.

The part shown in Figures 44 and 45, called ”*Rod*”, was created using *Extrude*, *Thread*, *Chamfer* and *Fillet* commands.

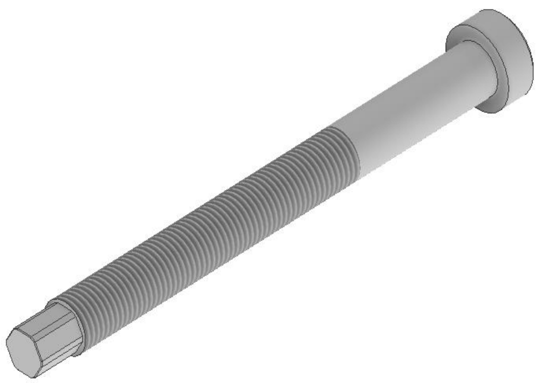

Figure 44 Rod - 3D model.

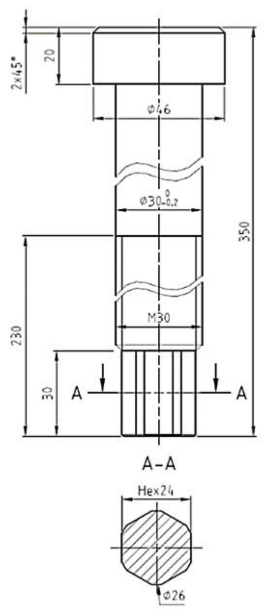

Figure 45 Rod - 2D model.

Figures 46 and 47 represent the ”*Lever*” assembly, consisting of two identical plates connected by two welded plates. The *Extrude*, *Fillet* and *Hole* commands were used in order to create the plates.

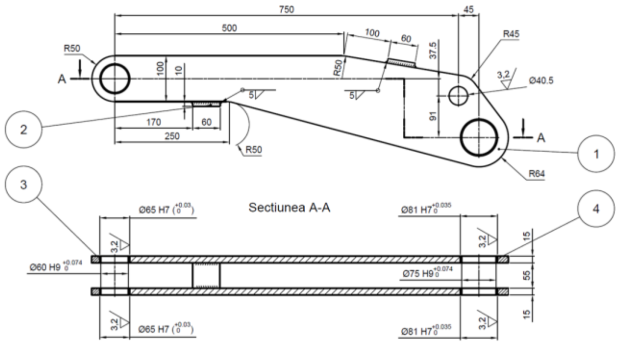

Figure 46 2D representation of the lever assembly:
1, 2 - plates; 3 - bush Ø65xØ60xØ15; 4 - bush Ø81xØ75xØ15.

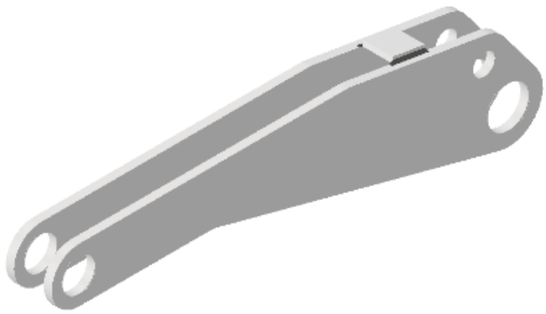

Figure 47 Lever assembly - 3D model.

In Figures 48 and 49 the ”*Rod*” assembly is represented, which consists of a retaining ring and the main body of the rod, the assembly being realized by means of welds. *Extrude*, *Chamfer* and *Thread* commands were used in order to create the rod and ring.

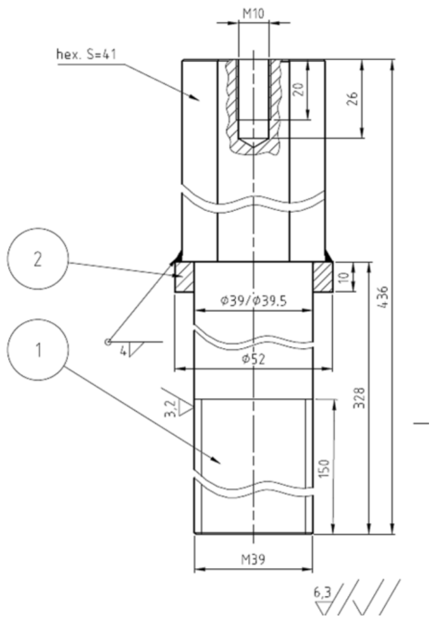

Figure 48 2D representation of the rod assembly:
1 - rod; 2 - ring.

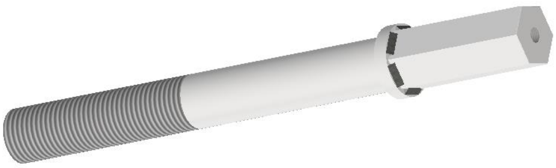

Figure 49 Rod assembly - 3D model.

Figures 50 and 51 show the ”*Rod blocker*” part that comes into contact with the rod assembly shown in Figures 48 and 49. The *Extrude*, *Fillet* and *Hole* commands were used to create this part.

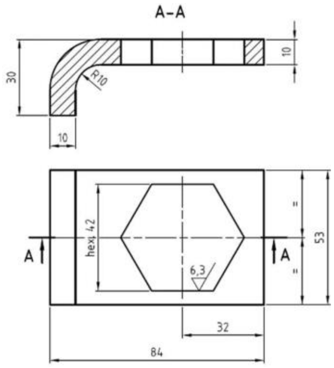

Figure 50 Rod blocker - 2D model.

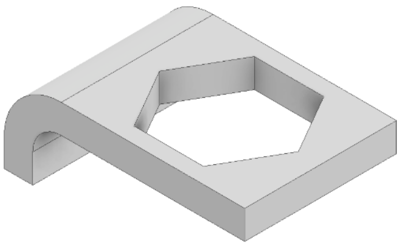

Figure 51 Rod blocker - 3D model.

The ”*Strip stopper*” assembly, presented in Figures 52 and 53, aims to prevent the strip from increasing its diameter beyond a certain value. The assembly is created from the main body of the strip stopper and the two screws, positioned as shown in the figures. The *Extrude*, *Hole*, *Fillet* and *Thread* commands were used to create the main body of the assembly.

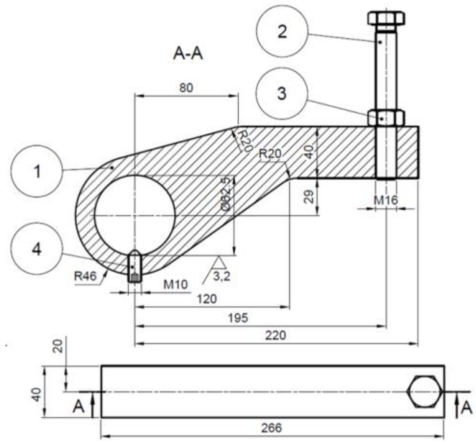

Figure 52 2D representation of the strip stopper assembly: 1 - plate; 2 - screw M16x120; 3 - nut M16; 4 - fixing screw M10x25.

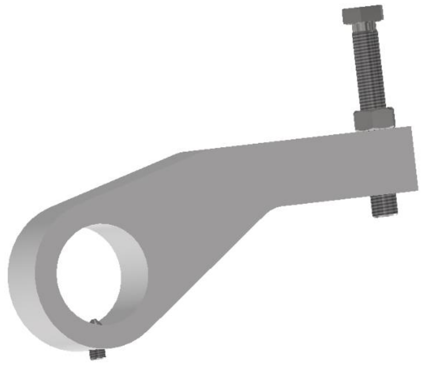

Figure 53 Strip stopper assembly - 3D model.

Figures 54 and 55 show the ”*Frame*” assembly, an element that was made by welding 5 plates, 4 of which serve as fixing elements, elements called ”*Ear type plate*”, which come in pairs of two, having different roles. Some ears are used to fix the frame to the rest of the assembly and the others are used to fix the pneumatic cylinders to the frame.

Figure 54 Frame assembly - 3D model.

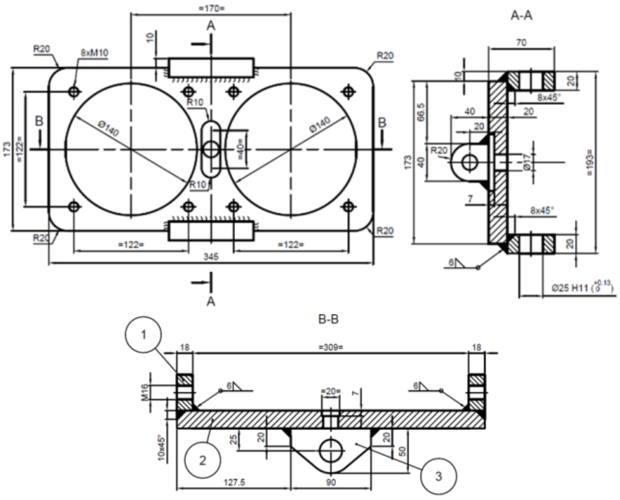

Figure 55 2D representation of the frame assembly: 1, 3 - ear type plates; 2 - plate.

The next element, shown in Figures 56 and 57, is called ”*Safety plate*” and its purpose is to reduce the freedom degrees of the bolt-type parts, namely the translation oriented along the axis of the bolt from the final assembly. The *Extrude*, *Hole* and *Chamfer* commands were used to create this part.

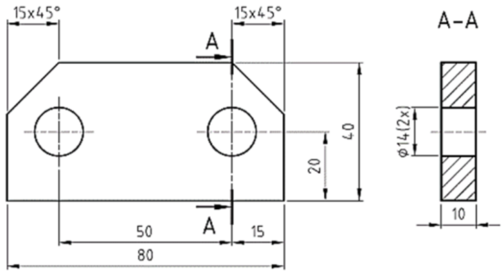

Figure 56 Safety plate - 2D model.

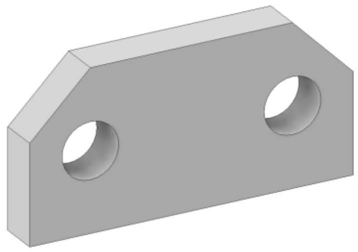

Figure 57 Safety plate - 3D model.

The next assembly shown in Figures 58 and 59, named "*Cleat assembly*" consists of a main part, to which a small parallelepipedal part was welded, with the purpose of spacing in the final assembly. In order to create the main part, the *Extrude*, *Fillet*, *Hole* and *Thread* commands were used.

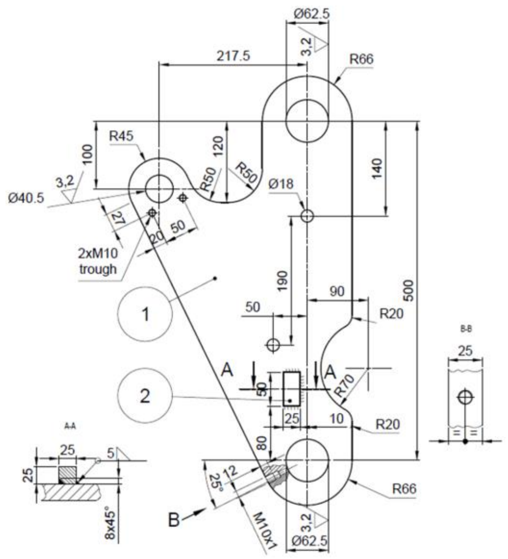

Figure 58 2D representation of the cleat assembly: 1, 2 - plates.

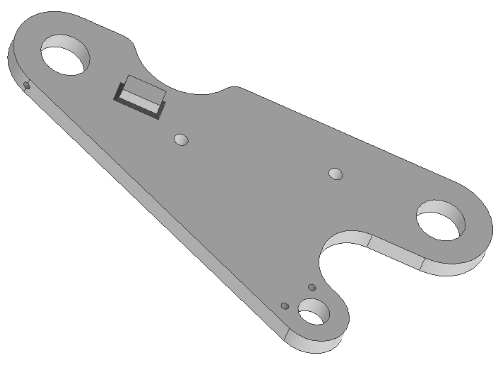

Figure 59 Cleat assembly - 3D model.

Presented in Figure 60 is the last element that forms the final assembly, named "*Brake band assembly*". This element serves to brake the winch on which it is located, by means of the frictional force exerted between the inner ferodo strip of the assembly and the winch.

Figure 60 Brake band assembly - 3D model.

The assembly is created from two semi-circular subassemblies, made up of a metal strip and a ferodo strip, of different sizes, brought into contact by a fastening element by means of screws at one end, and at the other end two pairs were welded of two ear-type plates, which serve to connect the subassembly to the rest of the brake components. The *Extrude*, *Hole* and *Fillet* commands were used to create the strip assembly parts.

Thus, Figure 61 shows the final assembly of the brake system, made in *Autodesk Inventor* program.

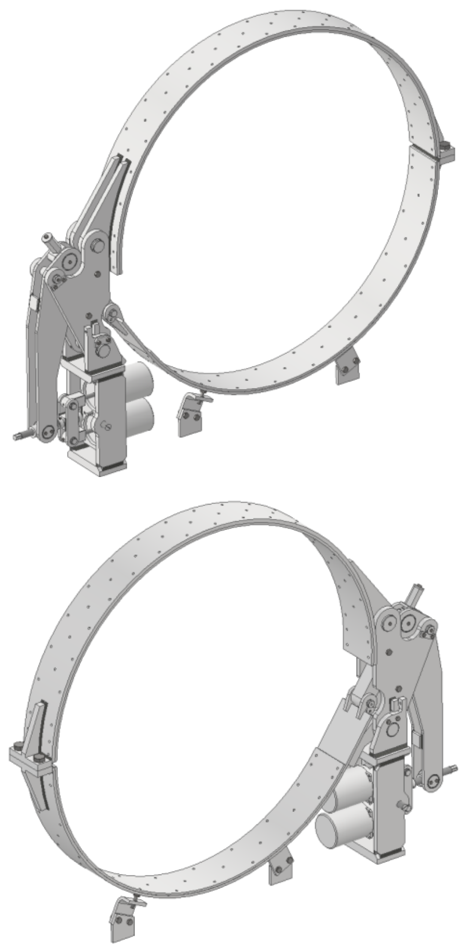

Figure 61 Band brake system - 3D model.

7. CONCLUSIONS

Band brake systems operated by pneumatic cylinders are a reliable solution for various industrial applications. Their efficiency, reliability and versatility enable them to effectively meet the varied needs of the industrial market, while ensuring superior performance and long-term sustainability. These advantages make band brakes an optimal choice for industrial applications that require robust, efficient and easy-to-maintain braking systems.

Also, the use of modern 3D graphic modeling technologies plays an important role in the design and optimization of these braking systems. Detailed modeling of each component allows precise verification of their compatibility and functionality prior to manufacturing. This process significantly reduces the risk of design errors, helping to increase the durability and performance of the final product.

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