Design and Fabrication of Typical Pipe Cutting Machine

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ABSTRACT

The Machine we designed and fabricated is used for cutting any shape of object like Circular, Rectangular, and Polygon. Hence our project namely Typical Pipe Cutting Machine is a Special type of Machine. According to the type of material to be cut, the cutting tool can be changed. This project gives details of Cutting various shapes and sizes of components. This machine can be widely applied in almost all type of industries. The pipe cutting process is a main part of the all industries. Normally the cutting machine is manually hand operated one for medium and small scale industries. In our project is pneumatically operated "**TYPICAL PIPE CUTTING MACHINE".** Automation in the modern world is inevitable. Any automatic machine aimed at the economical use of man, machine, and material worth the most. In our project is hand operated D.C valve and flow control valve is used for semi-automation. The pipe cutting machine works with the help of pneumatic double acting cylinder. The piston is connected to the moving cutting tool. It is also used to cut the small size of sheet metal. The machine is portable in size, so easy transportable.

Keywords

Pipe cutting machine, Automation, Pneumatic cylinder. Flow control valve, check valve.

1. INTRODUCTION

This is an era of automation where it is broadly defined as replacement of manual effort by mechanical power in all degrees of automation. The operation remains an essential part of the system although with changing demands on physical input as the degree of mechanization is increased. Degrees of automation are of two types, viz.

- Full automation.
- Semi automation.

In semi automation a combination of manual effort and mechanical power is required whereas in full automation human participation is very negligible.

1.1. Need for Automation

Automation can be achieved through computers, hydraulics, pneumatics, robotics, etc., of these sources, pneumatics form an attractive medium for low cost automation. The main advantages of all pneumatic systems are economy and simplicity. Automation plays an important role in mass production.

- Reduction of lab our and material cost
- Reduction of overall cost
- Increased production
- Increased storage capacity
- Increased safety
- Reduction in fatigue
- Improved personnel comfort

Automation or automatic control is the use of various control systems for operating equipment such as machinery, processes in factories, boilers and heat treating ovens, switching in telephone networks, steering and stabilization of ships, aircraft and other applications with minimal or reduced human intervention. Some processes have been completely automated.

The biggest benefit of automation is that it saves labour, however, it is also used to save energy and materials and to improve quality, accuracy and precision. The term automation, inspired by the earlier word automatic (coming from automaton), was not widely used before 1947, when General Motors established the automation department. It was during this time that industry was rapidly adopting feedback controllers, which were introduced in the 1930s. Automation has been achieved by various means including mechanical, hydraulic, pneumatic, electrical, and electronic and computers, usually in combination. Complicated systems, such as modern factories, airplanes and ships typically use all these combined techniques.

1.2. Types of automation

One of the simplest types of control is on-off control. An example is the thermostats used on household appliances.

Electromechanical thermostats used in HVAC may only have had provision for on/off control of heating or cooling systems. Electronic controllers may add multiple stages of heating and variable fan speed control. Sequence control, in which a programmed sequence of discrete operations is performed, often based on system logic that involves system states. An elevator control system is an example of sequence control. The advanced type of automation that revolutionized manufacturing, aircraft, communications and other industries, is feedback control, which is usually continuous and involves taking measurements using a sensor and making calculated adjustments to keep the measured variable within a set range.

2. AUTOMATION TOOLS

2.1. Introduction

Engineers can now have numerical control over automated devices. The result has been a rapidly expanding range of applications and human activities. Computer-aided technologies (or CAx) now serve as the basis for mathematical and organizational tools used to create complex systems. Notable examples of CAx include Computer-aided design (CAD software) and Computer-aided manufacturing (CAM software).

The improved design, analysis, and manufacture of products enabled by CAx have been beneficial for industry. Information, together

with industrial machinery and processes, can assist in the design, implementation, and monitoring of control systems. One example of an industrial is a programmable logic controller (PLC). PLCs are specialized hardened computers which are frequently used to synchronize the flow of inputs from (physical) sensors and events with the flow of outputs to actuators and events.

Different types of automation tools exist:

- ANN - Artificial neural network
- DCS - Distributed Control System

- HMI - Human Machine Interface
- SCADA - Supervisory Control and Data Acquisition
- PLC - Programmable Logic Controller
- Instrumentation
- Motion control
- Robotics

When it comes to Factory Automation, Host Simulation Software (HSS) is a commonly used testing tool that is used to test the equipment software. HSS is used to test equipment performance with respect to Factory Automation standards (timeouts, response time, and processing time).

2.2. Limitations to automation

- Current technology is unable to automate all the desired tasks.
- Many operations using automation have large amounts of invested capital and produce high volumes of product, making malfunctions extremely costly and potentially hazardous. Therefore, some personnel are needed to insure that the entire system functions properly and that safety and product quality are maintained.
- As a process becomes increasingly automated, there is less and less labour to be saved or quality improvement to be gained. This is an example of both returns and the logistic function.
- As more and more processes become automated, there are fewer remaining non-automated processes. This is an example of exhaustion of opportunities. New technological paradigms may however set new limits that surpass the previous limits.

2.3. Current limitations

Many roles for humans in industrial processes presently lie beyond the scope of automation. Human-level pattern recognition, language comprehension, and language production ability are well beyond the capabilities of modern mechanical and computer systems. Tasks requiring subjective assessment or synthesis of complex sensory data, such as scents and sounds, as well as high-level tasks such as strategic planning, currently require human expertise. In many cases, the use of humans is more cost-effective than mechanical approaches even where automation of industrial tasks is possible. Overcoming these obstacles is a theorized path to post-scarcity economics.

2.4. Why the need for Automation

Over the past several years, tools that help programmers quickly create applications with graphical user interfaces have dramatically improved programmer productivity. This has increased the pressure on testers, who are often perceived as bottlenecks to the delivery of software products. Testers are being asked to test more and more code in less and less time. They need to dramatically improve their own productivity. Test automation is one way to do this. The Promise of Test Automation Test automation implementations are expected to achieve some or all of the following objectives;

- Speed up testing to accelerate releases
- Allow testing to happen more frequently
- Reduce costs of testing by reducing manual labour
- Improve test coverage
- Ensure consistency
- Improve the reliability of testing
- Allow testing to be done by staff with less skill
- Define the testing process and reduce dependence on the few who know it
- Make testing more interesting; reduce the mundane repetitive execution of tests.
- This is the promise of test automation.

- The Reality
- Unfortunately, more often than not, automation implementations fail due for a number of reasons, the most common being;
- Effective test automation requires developer skills, already a rare commodity,
- Building a regression test suite requires significantly more time to develop than purported by the tool vendors,
- A reasonable maturity and competence in manual testing is lacking,
- Maintenance of the regression suite becomes unmanageable with the number of changes implemented in each release,
- The application must be available and stable before script development/ maintenance can take place,
- ROI on the tools and labour seldom, if ever, occurs in the short term,
- Test Automation Engineers are seldom included as an integral part of the development/test team,

The Test Automation Engineers automate the tests previously executed for each release, adding to the regression test pack. This results in a large number of (short) segmented automated tests.

2.5. Benefits of Industrial Automation

Automation, robotics, industrial automation, process control, and numerical control is the use of control systems such as computers to control industrial machinery and processes. Some advantages are repeatability, tighter quality control, and waste reduction, integration with business systems, increased productivity and reduction of labour. Some disadvantages are high initial costs and increased dependence on maintenance. Major benefits of industrial automation technology are the latest fieldbus developments. The most popular protocols are Device Net, Profibus and ASi and the emerging Industrial Ethernet. Implementation of industrial automation provides capital expenditure savings associated with cable elimination (multiple devices share wire-pairs and communicate over the bus network) and other savings are also available through speedier commissioning.

A major advantage of industrial automation and process control is the increased emphasis on flexibility and convertibility in the manufacturing process. Manufacturers are increasingly demanding the ability to easily switch from manufacturing a wide range of products without having to completely rebuild the production lines. Warehouses benefit from the marriage of automated guided vehicle technology and conventional industrial trucks. This system combines a very narrow aisle truck with guidance controls and software directed by the system controller. The driverless operation is capable of complete "lights out" operation from the warehouse receiving area to the shipping dock. Best of all, the vehicles can be introduced into current operations, using existing racking and floor.

2.6. Needs and Importance

The need for automation is felt because of the following reasons. These reasons emphasize on importance of automation. The reasons are:

- Automation facilitates efficient and detailed information through the use of mechanical aids like computers.
- It ensures speedy recording. Processing and presenting of information.
- Increased volume of work, scarcity of time and the slow manual processes necessitate the introduction of automation.
- It facilitates better quality work by reducing errors which are created on manual work.
- Revolution in office has been brought by automation because increased volume of work is handled in a better manner with greater accuracy and speed because of automation. This process results in increased output.

- Automation increases the goodwill and reputation of the firm because it adds to the prestige and status symbol of the enterprise.

2.7. Effects of Automation

Automation is suited to the developed countries of the world which have attained a state of full employment phenomenon. In those countries, automation becomes necessary because of scarcity of manpower. Automation is not suggested for a developing country like India because here the state of unemployment is visualized and automation will increase this state of unemployment. But automation should be introduced in post offices, railways, banks where the increased workload necessitates quick and accurate service to the public. Automation leads the following effects:

- Automation results in the state unemployment because human labour is replaced by mechanical work.
- It requires huge investment and as such it goes beyond the capacity of small scale firms to afford for automation.
- It brings about a complete change in the organizational structure and involves a great deal of additional cost.

3. WORKING PRINCIPLE

The compressed air from the compressor is used as the force medium for this operation. There are pneumatic double acting cylinders, Direction control valve and flow control valve. The arm from the compressor enters to the flow control Valve. The controlled air from the flow control valve enters to the D.C valve. The function of D.C valves to enter the air into the pneumatic cylinder.

The 5/2 D.C valve is used. In one position air enter to the cylinder and pusses the piston, so that the cutting stroke is obtained. The next position air enters to the other side of cylinder and pusses the piston return back, so that the releasing stroke is obtained. Figure 1 and 2 shows the typical pipe cutting machine

3.1. Applications

- This machine is very useful for small and medium scale industries
- This machine is used to cut the plastic pipes
- All Industrial Application

3.2. Disadvantages

- While working, the compressed air produces noise therefore a silencer may be used.
- High torque cannot be obtained
- Load carrying capacity of this unit is not very high.(<50 N)

3.3. Advantages

The pneumatic is more efficient in the technical field

- Quick response is achieved
- Simple in construction
- Easy to maintain and repair
- Cost of the unit is less when compared to other machine
- No fire hazard problem due to over loading
- Comparatively the operation cost is less

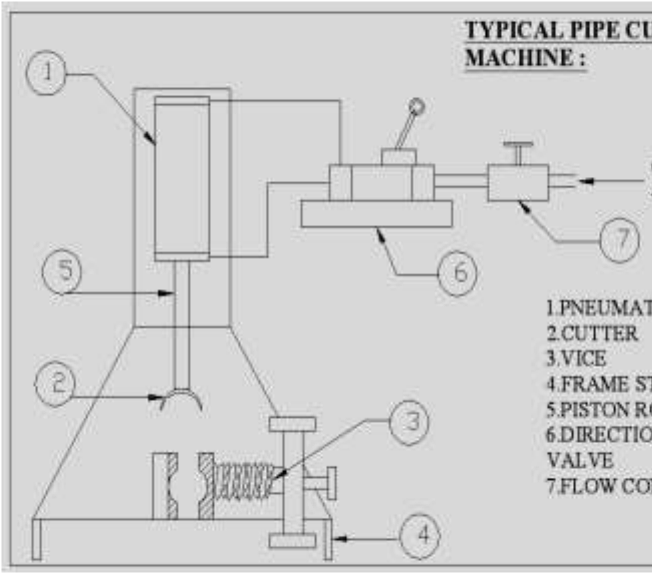

Figure 1.The typical pipe cutting machine

Figure 2.The typical pipe cutting machine

3.4. Specification of Double acting pneumatic cylinder

Technical Data

Stroke length : Cylinder stoker length 160 mm = 0.16 m

Piston rod : 18 mm = 18 x 10^{-3} m

Quantity : 2

Seals : Nitride (Buna-N) Elastomer

End cones : Cast iron

Piston : EN – 8

Media : Air

Temperature : 0-80 ° C

Pressure Range : 8 N/m²

3.5. Specification of Flow control Valve

Technical Data

Port size : 0.635 x 10²̥ m

Pressure : 0-8 x 10^5 N/m²

Media : Air

Quantity : 1

3.6. Specification of Connectors

Technical data

Max working pressure: 10 x 10^5 N/m²

Temperature : 0-100 ° C

Fluid media : Air

Material : Brass

3.7. Specification of Hoses

Technical data

Max pressure : 10 x 10^5 N/m²

Outer diameter : 6 mm = 6 x 10^{-3}m

Inner diameter : 3.5 mm = 3.5 x 10^{-3}m

4. PNEUMATIC CYLINDER

Pneumatic cylinders (sometimes known as air cylinders) are mechanical devices which use the power of compressed gas to produce a force in a reciprocating linear motion. Like hydraulic cylinders, something forces a piston to move in the desired direction. The piston is a disc or cylinder, and the piston rod transfers the force it develops to the object to be moved. 85 Engineers sometimes prefer to use pneumatics because they are quieter, cleaner, and do not require large amounts of space for fluid storage. Because the operating fluid is a gas, leakage from a pneumatic cylinder will not drip out and contaminate the surroundings, making pneumatics more desirable where cleanliness is a requirement. For example, in the mechanical puppets of the Disney Tiki Room, pneumatics is used to prevent fluid from dripping onto people below the puppets.

4.1. Cylinder design

The basic, rod-style industrial cylinder consists of a tube sealed by end caps. A rod attached to an internal piston extends through a sealed opening in one of the ends. The cylinder mounts to a machine and the piston rod acts upon the load. A port at one end of the cylinder supplies compressed air to one side of the piston, causing it (and the piston rod) to move. The port at the other end lets air on the opposite side of the piston escape — usually to atmosphere. Reversing the roles of the two ports makes the piston and rod stroke in the opposite direction. Rod-style cylinders function in two ways:

Double-acting cylinders use compressed air to power both the extend and retract strokes, moving the rod back and forth. This arrangement makes them ideal for pushing and pulling loads. Controlling the rate at which air exhausts determines rod speed. Single-acting cylinders have compressed air supplied to only one side of the piston; the other side vents to atmosphere. Depending on whether air is routed to the cap or rod end determines whether the rod extends or retracts. The most common type is pressure-extended, with an internal spring returning the piston to its original position when air exhausts. In other designs, gravity or an external spring powers the return stroke.

Repairable cylinders can be disassembled to replace seals and other internal components. This extends a cylinder's life. These durable cylinders are generally used in rugged, heavy-duty applications. Sealed-for-life or "disposable" cylinders have end caps mechanically crimped to the tube. Internal components are preluded prior to assembly. Although they are less expensive to manufacture than comparable repairable cylinders, they cannot be taken apart to repair without destroying the housing. These cylinders are usually used in lighter-duty applications and must be replaced when they fail. Compact cylinders fit into smaller spaces where only a short stroke is required. They are used in lighter-duty applications due to the small bearing surface on which the rod slides. They mainly come in single-acting versions, but double-acting styles also are available.

Guided cylinders have guide rods and guide blocks mounted parallel to the piston rod, or dual piston rods. They prevent the piston from rotating and provide precise, controlled linear motion — especially when the unit is subject to high side loads. In such cases, the guides reduce rod and piston bending and uneven seal wear. They are recommended in applications with sizeable offset loads or require that the load be guided, for example, down a conveyor.

Rack-and-pinion units convert a cylinder's linear motion to angular rotation that can exceed 360°. The rotary actuators — with the rack mounted on the rod — are often used in process industries to operate quarter-turn valves. Bellows are durable, single-acting actuators with flexible, reinforced-elastomeric walls and metal end plates. They extend when inflated and can generate high forces, thanks to their large diameters. A cylindrical shape lets them bend in any direction, making them useful where load direction might curve. Note that external restraints should be used to limit maximum extension and compression. Unrestrained extension can blow off the end plate, and exhaust without restraint can let the load crush the sidewalls.

Rodless cylinders, as the name implies, have no rod extending through the end caps.

Instead, an external carriage slides back and forth on the tube. The load mounts on this carriage. In many designs, an internal piston is mechanically connected to the carriage through a sealed longitudinal slot in the cylinder wall. Long sealing strips inside and outside the cylinder tube prevent air leaks and dust and dirt ingression. Other variations include cable-and-pulley arrangements and magnetically coupled pistons and carriages.Rodless cylinders are well suited for applications with long strokes or high moment loads. They save space because the stroke is contained within the cylinder's overall envelope. Most manufacturers offer several carriage designs. Three of the most common are internally guided, externally guided, and precision-roller guided.

4.2. Force output

Another key selection criterion is how much force a cylinder generates. Determine this from the air pressure and bore size (the ID of the cylinder.).A general rule of thumb is that for vertical and high-friction applications, the required force should be twice the load to be moved. In some cases additional force is necessary to compensate for friction.

Designers can calculate cylinder force by multiplying the effective piston area by the working pressure. The effective area for push force is the cylinder bore. For pull, it's the bore area less the cross-sectional area of the piston rod. Thus, theoretical push force is:

$$F = \pi\ (D2/4 - d2/4)\ P$$

where

F = force, lb;

D = cylinder bore, in.; and

P = pressure, psi.

Theoretical pull force is:

$$F = \pi\ (D2/4 - d2/4)\ P$$

where

d = piston rod diameter, in.

Force calculations get more complicated in single-acting cylinders with a spring. The force opposing the push or pull increases as the stroke progresses. In practice, manufacturers' catalogs often list push and pull values for both double-acting and single-acting cylinders, simplifying calculations for users. When estimating the relative force of cylinders with different bore sizes, remember that thrust increases with the square of the diameter. In other words, doubling the bore will quadruple the thrust.

Speed

Speed affects productivity, longevity, and controllability. Calculate the stroking speed of a pneumatic cylinder from:

$$s = 28.8q/A$$

where

s = speed, ips;

q = airflow in standard cubic feet/minute; and

A = piston area, in.m^2

Other factors that might affect speed include port sizes, inlet and exhaust flow through control valves, and hose or tubing sizes — if they create bottlenecks that restrict air flow to or from the cylinder. Likewise, air pressure that is barely capable of moving the load will hamper speed.

With any fixed combination of valve, cylinder, pressure, and load, it is usually necessary to have adjustable control over cylinder speed. Flow controls at the cylinder ports let users tune speed to their application. For most applications, unidirectional flow regulators installed to restrict flow out of the cylinder and permit free flow in give the best results. A regulator in the rod-end port controls extension speed, and one on the cap-end port controls retraction.

4.3. Air consumption

Calculating a cylinder's air consumption is often necessary on fast-cycling equipment to ensure enough supply air is available. There are two parts to cylinder air consumption. One is the volume the piston displaces. The other is the unswept volume from end-cover cavities, cylinder ports, connecting tubing, and valves. The unswept portion is likely to be a small percentage of the total and will vary with the installation.It's best to ensure the compressor has sufficient capacity to supply pneumatic equipment under “worst-case” conditions. Otherwise, air starvation at critical times will cause performance to suffer.

4.4. Additional considerations

After sizing a cylinder for force and stroke, engineers have a lot of leeway in tweaking a cylinder so it best fits an application. Here are a few considerations.

Port sizes and locations are usually dictated by bore size, but can be adjusted in custom designs. Envelope dimensions. The National Fluid Power Assn. and International Standards Organization have established standards for many cylinder dimensions, letting engineers interchange cylinders from different manufacturers. Many models also have unique dimensions.

Mounting configuration refers to how a cylinder attaches to the adjacent equipment. The large number of standard mountings — both rigid and articulated — usually ensures a cylinder can execute the specific movements an application requires.

4.5. Cylinder materials.

The operating environment is the major factor that governs material choice. Pneumatic cylinders are typically made of steel, aluminum, stainless steel, brass, or engineered plastics. Some models combine several materials.

Seal materials. Cylinder manufacturers use a variety of methods to seal the end caps and rod. Designers can specify alternative seal materials for applications that operate in extreme high or low ambient temperatures or are exposed to caustic chemicals.

Position feedback. Magnetic cylinders have a band of magnetic material around the circumference of the piston and a nonmagnetic cylinder barrel. The magnetic field travels with the piston as the rod strokes in and out. Mounting reed switches on the outside of the barrel — one at each end, for example — generates a signal each time the piston completes a stroke. More-advanced versions use LVDT transducers or LRT linear potentiometers to provide continuous indication of piston position.

Cushions. If the piston makes metal-to-metal contact with the end covers, the result is noise and potential mechanical damage. Cushions in cylinders prevent such contact. Adjustable cushions let operators control the rate at which cylinders decelerate at the end of stroke.

Some cylinders have integral fixed cushions. They have a pre-engineered fixed cushion orifice that restricts exhaust airflow to slow the piston at the end of stroke. The amount of cushioning is repeatable but cannot be altered in the field.

Only use non cushioned cylinders at slow speeds. To operate non cushioned cylinders faster, install external stops with shock absorbers. Position these to prevent contact between the piston and end covers.

4.6. Cautionary tips

An important design consideration is to keep cylinder thrust as close as possible to the centreline of the piston rod and free from misalignment or side thrust. Cylinders are normally intended to push and pull without excessive side loads. Off-center loads can substantially reduce the service life of rod bearings and seals.Off-center and side loading are caused by improper mounting, cylinder deflection under load, machine frame deflection, and rod bending or sagging — as well as by poor machine design. Sometimes adding an optional internal stop tube can reduce a cylinder's bearing load. A stop tube is a spacer between the piston and rod-end head. It increases the distance between the piston bearing and rod bearing when the rod fully extends. This configuration also helps in long-stroke applications.

If the piston rod sees compressive axial loads, care must be taken to ensure its length, diameter, and load are within safe limits to prevent the exposed rod from buckling.

Most pneumatic cylinders are assembled with a coating of grease on the bore of the barrel and seals for service with non-lubricated air. If the compressed air supply is clean and dry, the grease will give the seals a long life without adding oil through an airline lubricator. However, contaminated air will gradually compromise the original grease lubricant and shorten seal life.

Lubricated air will extend the life of the cylinder, but it will also wash out the original lubrication. So once lubricated air is introduced, it must always be used, and the lubricator should be regularly checked and maintained.

4.7. Advantages and disadvantages

The main advantages of automation are:

- Increased throughput or productivity.
- Improved quality or increased predictability of quality.
- Improved robustness (consistency), of processes or product.
- Increased consistency of output.
- Reduced direct human labour costs and expenses.

The following methods are often employed to improve productivity, quality, or robustness.

- Install automation in operations to reduce cycle time.
- Install automation where a high degree of accuracy is required.
- Replacing human operators in tasks that involve hard physical or monotonous work.
- Replacing humans in tasks done in dangerous environments (i.e. fire, space, volcanoes, nuclear facilities, underwater, etc.)
- Performing tasks that are beyond human capabilities of size, weight, speed, endurance, etc.
- Economic improvement: Automation may improve in economy of enterprises, society or most of humanity. For example, when an enterprise invests in automation, technology recovers its

investment; or when a state or country increases its income due to automation like Germany or Japan in the 20th Century.

- Reduces operation time and work handling time significantly.
- Frees up workers to take on other roles.
- Provides higher level jobs in the development, deployment, maintenance and running of the automated processes.

The main disadvantages of automation are:

- Security Threats/Vulnerability: An automated system may have a limited level of intelligence, and is therefore more susceptible to committing errors outside of its immediate scope of knowledge (e.g., it is typically unable to apply the rules of simple logic to general propositions).
- Unpredictable/excessive development costs: The research and development cost of automating a process may exceed the cost saved by the automation itself.
- High initial cost: The automation of a new product or plant typically requires a very large initial investment in comparison with the unit cost of the product, although the cost of automation may be spread among many products and over time.

In manufacturing, the purpose of automation has shifted to issues broader than productivity, cost, and time.

CONCLUSION

Pipe cutting, or pipe profiling, is a mechanized industrial process that removes material from pipe or tube to create a desired profile. Typical profiles include straight cuts, mitres, saddles and midsection holes. These complex cuts are usually required to allow a tight fit between two parts that are to be joined via arc welding.

Cutting is performed by means of a thermal torch (plasma or ox fuel) and is mounted to the last axis of a multi-axis machine. The axes of the multi-axis machine are powered by electric motors and are synchronized to create a path for the torch and pipe that yield a desired profile. The synchronization of axes is accomplished either mechanically, via cams, levers and gears, or electronically, via microprocessors and controllers.

Pipe cutting machines are popular in offshore, pipe processing, ship building, pressure vessel, structural and mechanical contracting manufacturing because of the complex cuts and profiles typical required in their respective industries. Some common pipe cutting applications are: pipe work, offshore jackets, industrial steel structures, stadiums, cranes, nozzles, and pipe laying stingers.

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