STUDY OF DESIGN & DEVELOPMENT OF OXYGEN SUPPLY SYSTEM FOR CNC GAS CUTTING MACHINES

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Abstract- In heavy fabrication company, manufacturing of boiler and cement shells, CNC gas cutting machine is regularly used for various plate cutting operation. Such machines require oxygen and acetylene gases with proper pressure controls. For gas cutting machine, volume of oxygen gas used is more than that of acetylene gas. The oxygen gas is used for heating and cutting the plates. It is necessary to supply the proper amount and quality of gas to the machine to obtain good cutting quality of plates. Even the pressure of oxygen gas depends upon the thickness of cutting plates.
Previously using twelve cylinders manifold and common pipeline for both the gas cutting machine was common. In this system, the cylinder gets empty in 16 hours, so after every 16 hours there was a necessity of changing the twelve cylinders. Thus, the paper presented provides us with the detailed information about the automated oxygen supply system called oxygen bullet Thus, the paper presented provides us with the detailed information about the automated oxygen supply system called oxygen bullet

Keywords- Oxygen Bullet, Piping Systems, Vessel Dimensions, Pressure Ratings And Burst Strength.

I. INTRODUCTION

This paper shows the difference between old operating system and modified operating procedure for CNC gas cutting machines. With this experiment mainly operator idle hours are reduced as well as labor fatigue and machine down time cost by making changes in the existing process of plate cutting machines have been drastically reduced.
The main objective of this experiment is to maintain quality in products and service, as well as our low cost structure. It is one of the oldest welding processes, besides forge welding. Still used in industry, in recent decades, it has been less widely utilized in industrial applications as other specifically devised technologies have been adopted. It is still widely used for welding pipes and tubes, as well as repair work. It is also frequently well-suited, and favored, for fabricating some types of metal-based artwork.
In the old oxygen supply system the time taken to change the cylinder leads to machine downtime, labour fatigue and operator idle hours. Due to this there is a huge loss of production and time.
Thus, in order to reduce such losses, we installed automated oxygen bullet. With the help of this bullet, machine downtime and labour fatigue is drastically reduced.

Fig. 1 CNC Gas Cutting Machine

There are wide ranges of CNC profile cutting machines. These machines have a modern gantry type dual drive CNC profile cutting system suitable for oxyacetylene and plasma cutting applications. These are available in different sizes, which accommodate cutting widths from 2 meters to 6 meters with a cutting speed range 70-4000 mm/min and also with

rapid traverse of 10,000 mm/min. For our clients benefit, motorized torch with auto height sensing, is available for oxy-fuel or plasma torches. The machine can accommodate 4 - 6 torches depending on the size of the machine. These machines can further be supplied with a choice of plasma cutting equipment to individual customer requirements with an internationally proven drive system. The longitudinal drive is a dual drive through rack and pinion. The transverse drive is rack and pinion for the Master cutter post and through a belt drive system for the subsequent torches.
This system consists of twelve cylinders which are arranged in series as shown in figure. Each cylinder is connected to the common pipeline with hose. It consists of 12 joints which is of high precision fittings.

It is provided with the valves. Here two main valves are used to deliver the oxygen gas from the cylinder. Above the valves, it is provided with the pressure regulator valve at the top. The function of regulator valve is to adjust the pressure of the oxygen gas as per the requirement. It is used as a safety valve. Here the regulator of the oxygen gas is done. This pressure adjustment is carried out by adjusting the knob present on top of the valve.The gauge is used to indicate the pressure so that the user can adjust the pressure easily. As this system consists of 12 cylinders, it gets empty within a short period of time.

If there is any leakage observed it may get into a loss of gas which in turn leads to empty cylinder. To connect the new cylinder, the cylinders are transported from the storage area where numbers of cylinders are stored. Here the proper care should be taken while handling the cylinders.

II. PROBLEM IDENTIFICATION

As Mentioned earlier, the 12 cylinder manifold system is a very complex and time consuming process. During the refilling of the cylinders the machine idle time is increased to a huge amount as well as the time required for the transportation of the cylinders from storage to manifold area is quite high. Labor fatigue is immense and the handling of the oxygen cylinders is also a risky task. Due to oxygen cylinders the efficiency of the gas cutting machines is very poor and the resulting pressure is approximately 8-10 bars. Generally, gas cutting machines are used where heavy materials are to be cut or complex shapes are a demand. As the oxygen cylinders have a limited capacity refilling is one of the most important aspect. The supply of oxygen cylinder usually lasts for 12-15 hours. Thus, it becomes difficult for the machine operator to stop the machine and change the cylinder. This paper work is based on a live project carried out in a large scale fabrication industry.

2.1. Types of Cutting Processes

Metals may be cut by
(i)Mechanical means (Machining)
(ii)Chemical reaction (oxidation) - Oxygen cutting
(iii)Melting (Arc action) - Arc cutting.
Although all the three methods are used in welding process, the latter two, i.e., (ii) and (iii), are closely allied with welding processes.
Oxygen cutting is a group of cutting processes wherein the severing or removing of metals is affected by means of the chemical reaction of oxygen with the base metal at elevated temperatures. In the case of oxidation resistant metals, this reaction is facilitated by the use of a chemical flux or metal powder.

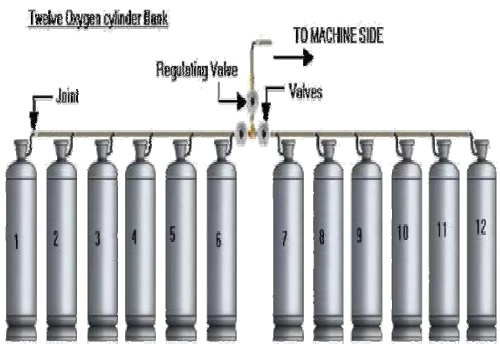


Fig. 2 Diagrammatical representation of Oxygen supply system (old)

2.2 Principle of operation of Oxyacetylene Machine:

The oxyacetylene flame cutting process makes use of a cutting torch. The mixture of acetylene and the oxygen in correct proportions to produce a preheating flame and also the torch supplies a uniformly concentrated stream of high purity oxygen (known as cutting oxygen) to the reaction zone. After a spot area along the line of cut is heated to ignition temperature (900°C), i.e., reddish yellow color the preheat flames, keeping the flame cones 1.5 to 3 mm above the surface of material, to be cut, a thin jet of high purity oxygen is then directed or shot at this heated spot. The jet quickly penetrates through the steel. The iron and oxygen combine to form iron oxide. The oxygen jet blows the reaction products from the joint and thus the torch moves progressively forward over the metal surface, cutting a narrow slot or kerf along the desired line of severance. In actual practice, the top surface of the material is frequently covered with mill scale or rust. They must be melted away by the preheating flame to expose a clean metal surface to the oxygen jet. The cutting action is self progressing provided the (cutting) oxygen jet is sustained and the pre heating flame is maintained on the top surface of the metal object being cut.

III. EXPERIMENTAL DETAILS
CONCEPT OF MODIFIED OXYGEN SUPPLY SYSTEM (OXYGEN BULLET)

The symbol for Oxygen is O2. Atomic weight of oxygen is 16 and atomic no. is 8. Oxygen gas is non-metallic element. It was apparently first obtained in 1727 by Stephen Hales. Oxygen is colorless, odorless and tasteless. Oxygen reacts with all elements, but not with inert gases to form compound called oxides. Oxygen support combustion and support flammable materials to burn more rapidly. And this combustion supporting property prefers it for different industrial applications. In atmosphere about 21% of oxygen is present. Pure oxygen is extracted from air. When atmospheric air is compressed through a series of venturies the different gases in air begin to separate at different temperature. When natural air freezes and temperature reaches to –297 degrees Fahrenheit oxygen is in liquid form. Liquid oxygen has a density of 1140 kg/m³. For industrial applications oxygen is obtained from air by fractional distillation process.

Properties of Liquid Oxygen in the modified system

Sr. no	Properties	Quantity
1	Content in air	21 Vol%
2	Gas density at 1013 bar and 15°C	1.36 kg/m3
3	Boiling temperature at 1013 bar	-183°C
4	Liquid density at 1013 bar and boiling temp.	1.14 kg/l

DESIGN OF INSTALLATION:

Installation of Oxygen Bullet

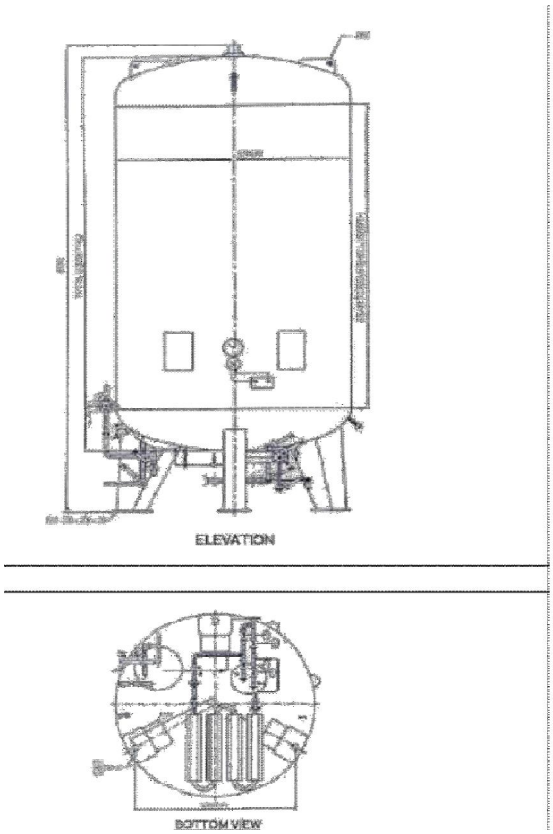
General Requirements for installation:
Installations shall be designed, manufactured and installed in accordance with recognized pressure vessel, storage tank, piping and building codes and where appropriate in accordance with statutory requirements.

(a) Pressure Relief Devices
Pressure relief devices shall be provided to prevent overpressure especially as pressure extremes can cause structural failure of the tank and release of contents. To define the capacity of pressure relief devices all operational and upset conditions in the worst foreseeable combination must be considered.
The design relieving flow capacity Qs for each inner tank relief device shall consider the following formula,
Where,
Qv = the sum of all the flows in normal operating conditions Qv that are expected to be simultaneous, and
Qa = the highest flow generated by upset conditions
Normal Operating Conditions Qv to be considered are, for example:
Normal boil-off rate from ambient heat leak.
Liquid flash and gas displacement from plant production.

Liquid evaporation during cool down or recycling of pump systems for loading road trailers and rail tank cars (if performed for the particular tank installation)
Liquid flash and gas displacement from unloading road trailers or rail tank cars into the tank (if performed for the particular tank installation)
Vapor return from loading tank trucks
Cool down of lines and connected equipment. Upset Conditions Qa should include the largest of the following independent upset conditions.

Malfunction of control valves in the pressure control circuits or filling line causing excess vapor generation in the tank.

Substantial decrease in barometric pressure.
Liquid production sub-cooling defects.
Excessive rate of cool-down of discharge lines.
External fire.



Construction of Oxygen bullet

Components of Oxygen bullet
Inner vessel
Vacuum jacket
Heat Exchanger
Evacuation connection
Condenser
Liquid O_2 filling connection
Liquid level indicator
Pressure Regulator and gauge
Pressure reducing system
Vacuum probe
Outer jacket rapture disc

Working of Oxygen Bullet:
The pressure vessel is suspended inside a vacuum jacket and insulated with pearlite powder under high vacuum. The insulation space vacuum can be measured by connecting vacuum gauge to vacuum probe located on lower head of tank. The liquid and gas phase lines to pressure vessel pass through the lower head of vacuum jacket. The inner vessel & piping is constructed of stainless steel. The vacuum jackets and leg supports are made of structural steel.

The tank can be filled through two fill valves. Filling through gas phase fill valve on top of pressure vessel tends to reduce tank pressure and through liquid phase fill valve on bottom of vessel tends to increase tank pressure. The vent valve is opened for venting and throttled to maintain desired tank pressure during filling. The overflow valve is used to terminate filling process. Tank pressure is indicated by pressure gauge and product level is indicated by liquid level indicator. The pressure building system provides constant preset tank pressure when liquid phase and gas phase lines are open. Withdrawing product from tank reduces tank pressure and when tank pressure reduces to pressure building regulator set point, the regulator opens and liquid flows from liquid phase valve to pressure building vaporizer. The coil vaporizes the liquid and tank pressure is increased by allowing gas to return to top of tank.

Vessel dimensions

DIMENSION (mm)	INNER VESSEL	OUTER VESSEL
HEAD OD	1150	1600
HEAD THICKNESS	6	8
SHELL OD	1150	1600
SHELL THICKNESS	2550	3360
SHELL LENGTH (SEAM TO SEAM)	2550	3360
TOTAL LENGTH (L)	3195	4040

PIPING SYSTEMS

All piping systems should be designed in accordance with given specifications and the latest issue of the applicable ANSI code. The design should be based on the pressure and temperature of the system and the pressure and temperature limitations of the materials selected. All local, state, and federal codes shall be considered. High-pressure oxygen shall not be transmitted in buried piping. Underground piping cannot be inspected as readily as visible piping for leaks, corrosion, or other defects. Oxygen piping and equipment shall be installed at a distance from electric power lines or electrical equipment, far enough so that any failure of the power lines or electrical equipment will not permit contact with the oxygen piping and equipment. All oxygen piping must be adequately supported to avoid excessive vibration and to prevent deterioration by friction. Piping and pressure-containing components should be consistent with the accepted design philosophy, substantiated by the following. Stress analysis to predict safe and reliable operations per codes. Pressure testing codes to verify performance. Extensive successful service experienced under comparable design conditions with proportional and similar shaped components.

Internal Lines of the oxygen bullet

ITEM	Description
A	Top Fill Line
B	Bottom Fill Line
C	Auxiliary Liquid withdrawal
D	Siphon Withdrawal Line
E	Liquid Instrument Line
F	Gas Instrument Line
G	Full Try cock Line
H	Safety Line
I	Economizer Line
J	Vapor Return Line

2.8 Pressure Ratings & Burst Strength

In the ASME Code for Pressure Piping (ASMEB31):

P=25(tmin-C)

Dmax 0.8(tmin-C)

Where

P=allowable pressure in psi

S=allowable stress

t_{min}=wall thickness (minimum)

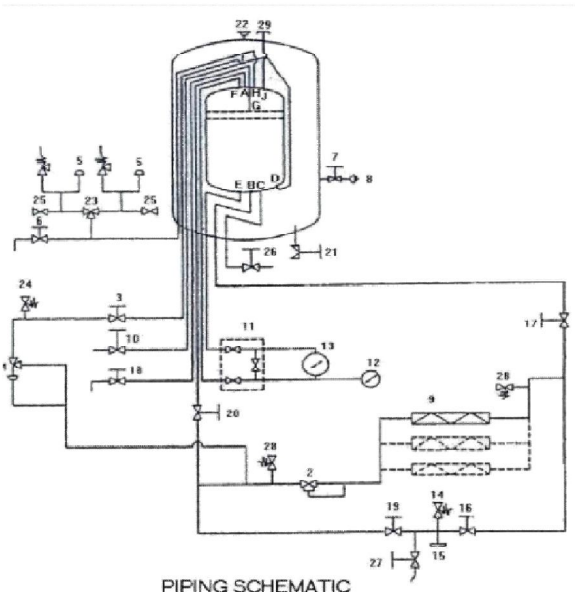
D_{max}=outside diameter

C=constant because of copper's corrosion resistance the B31 code permits C=0 and the formula is,

$$P=2St_{min}$$

Here S=allowable design strength for tube material

Circuit diagram indicating Oxygen supply to the machine



IV. RESULTS & DISCUSSION

Due to the newly modified automated system the efficiency of the CNC gas cutting machines has been

drastically increased. The pressure of the oxygen gas with which the raw material is cut is also increased from 8 bar to 11 bar. Thus, this increase in pressure helps to cut the materials with heavy thickness as well as any types of complex and intricate shapes can be cut with greater ease. Consequently due to the automated system the the capacity of oxygen has been increased and it has become easy to refill the oxygen bullet every 15 days rather carrying out the same process daily (as in the case of old manifold system) resulting in huge amount of cost savings as well. The data is represented in the following table.

Statistical Data of the New System

1	Time required to loading the bullet	30mins.
2	Time period between two loadings	15 days.
3	Cylinder movement	Nil.
4	Gas cutting quality	Good
5	Labour fatigue	Nil.
6	Machine down time	60min/ month
7	Saved labour cost in Rupees	Rs. 7750/-
8	Safety – Chance of cylinder fall	Nil.
9	Leakage by manual mistake	Nil.
10	Chance of material scrap	Nil.
11	Machine running cost saved in Rupees	Rs.32250/-

Per Month
(45Min/Day x 30 days = 1350Min.)
(1350Min/ 60Min = 22.5Hrs.-1Hr=21.5Hrs.)
(21.5 X 1500 Rs = 32250 Rs)
(The above stated data is subjected to a case study performed in the industry. The statistical values may change according to the industry requirements)

CONCLUSION

The concept of project was included in our engineering syllabus with the view to inculcate within us the application ability of the theoretical concept of design & production engineering to practical problems. It helped us to learn and work more as a team rather than an individual.

In completing this experiment "DEVELOPMENT OF OXYGEN SUPPLY SYSTEM FOR CNC GAS CUTTING MACHINE" as per time estimates gives us immense pleasure and a feeling of achievement. During the course of project we encountered numerous problems, which we overcame with the able guidance of our company co-members & project guide.

This project report presents a brief mention of our efforts. It has given us a good exposure to the practical field, which in the future is definitely going to help us.

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