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# Design of Welding Fixtures and Positiners

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**Abstract**:- Robotic welding requires specialized fixtures to accurately hold the work piece during the welding operation. Despite the large variety of welding fixtures available today the focus has shifted in making the welding arms more versatile, not the fixture.The new fixture design reduces cycle time and operator labor while increasing functionality; and allows complex welding operations to be completed on simple two axis welding arms

**Keywords**:- fixtures**,** positioners, welding, drop center, CNC, CMM, CAD simulation, automation

## 1. Introduction

Fixed Automation welding is often applied to welding equipment performing dedicated movements on a weld joint that is highly repeatable in shapes such as circle, arc and longitudinal seams [8]. The welding machine systems can be flexible and can be adapted to a differing range of weld automation application. The weld equipment operations are normally fixed to perform a basic geometric welding application. Welding position equipment and machine systems are backbone of fixed welding automation usually including welding lathes, turn tables positioners, circle welders, and longitudinal seam welders. To address this issue, we designed and constructed a prototype welding fixture with enhanced mobility[4]. The principles of positioning are the same for all weldments, large and small. Many companies extends their expertise in designing and manufacturing of sheet metal welding fixture, assembly fixture, checking fixture, inspection fixture and cater to the requirements of a single fixture to turnkey solution. They have expertise in design and manufacturing of manual, pneumatic, hydraulic fixture along with installation and commissioning. With the help of sophisticated CAD and Simulation tools feasibility study is carried out inclusive of gun approach, weld study and line layout. All fixtures are validated and supported within house CMM equipment reports for record.

The latest developments from the prototype manufacturing International standards find their way into the series production of all major vehicle manufacturers. A highly flexible robotic welding system is supporting the chassis specialist to make process and manufacturing operations ever more efficient.The complex nature of the welding process due to multi-field (thermal, mechanical, metallurgy etc.) interactions and intricate geometries in real world applications has made the prediction of weld-induced imperfections, a truly difficult and computationally intensive task. In industries it is however, with the availability of 64 digit computers and refined FE tools, welding engineers around the world are more biased towards the computer simulations of complex welding phenomenon instead of the conventional trial and error approach on the shop floor is the most common practice nowadays [3]. A significant simulation and experimental work focusing on circumferential welding is available in the literature. As the computer simulation of welding processes is highly computationally intensive and large computer storage and CPU time are required, most of the previous research reduces computational power requirements by simplifying with assumptions such as rotational symmetry and lateral symmetry in numerical simulations. These assumptions reduces the computational demand at the cost of the accuracy of the results because the model was over simplified by limiting the solution domain to only a section of the whole do-main with forced symmetry assumptions which did not prevails.

## 2. Basic Study of Welding Fixtures and Positioners

There are all types and designs of welding positioners; some have fixed tables that are always vertical, which are called headstock positioners. The type where the table tilts on geared segments that also rotate and a variable speed in both directions are most often just called welding positioners. These are used to weld and position everything from pipe to tanks just about anything that you need to rotate or position in the flat for a smooth fluid smooth weld.This often gives welders faster welding speeds with better x-ray quality welds Most of the positioners are rated with what is called C.G.(centre of gravity) and this will vary from type and designs of positioners. The centre of gravity is a indicator of the amount of torque that the positioner has for rotation purposes. The tilting

positioners also are rated for the amount of tilt torque. The rating is not only from the face plate away, it is also the rating from the centre of the positioner table out. This is a important factor if you are going to be welding offset loading like pipe elbows and Tees.

If your positioner is not sized correctly the rotation speed of the positioners table with speed up and slow down. If your positioner does this you could be doing damage to the motors and gear box of the positioner. You seldom hear a welding fabricator complain they have to large of a weld positioner.Over time this will also cause the ring gear and other positioner parts to wear more quickly causing sloppy rotation and at some point failure of the welding positioner's parts. If this is happening you need to either look at purchasing a larger or a positioner with higher torque. This will insure smooth welding table rotation making for better quality welds and also easier on the welder. If you are doing longer concentric parts like splicing pipe you can use out board support stands to overcome the centre of gravity rating of the positioner. This is a common practice even when the load is with the positioners rating. It just helps the fabrication shop keep the positioner is quality working condition. USA built positioners tend to be rated at a C.G. of 4" - 6" and 12" away from the centre of the table as well as away from the welding table face plate.Things to ask about when you are buying a welding positioner are where it was built, what is spare parts availability.

What is the warranty and does that cover parts install in shop or as most USA manufactures the install is part of the warranty if it is shipped back to the manufacture. Many will send the part and you can install and get compensation for a fair labour cost. Import positioners have been known to have long lead times for parts and those brands also unlike most made in the USA positioners do not always use common standard parts. One might buy a positioner and find they have different drives, motors and gear boxes. This is often time consuming to identify what part is needed. This can be time consuming and frustrating when replacement parts are needed. Some of the imports are very low cost, using cheaper gear boxes, drives, motors and inferior steel.But the low cost is soon forgotten when the positioner stops working. You also find out the gear box or electrical parts all do not match from positioner to positioner even though they maybe even the same model. Most if not all positioners built in North American are built too much higher standards than many of the far -east imports. When looking at purchasing a large or small welding positioner ask where it is built. Equipment made in the USA are manufactured to a higher standard than many of the imported models you will find at your national supply big box stores that tend to sell all type of unrelated equipment [5].

5 important things a welder needs to know about weld positioners when selecting, operating and maintaining positioner.

2.1. Remember the CG:-

•Selecting right positioning device for job involves accounting not only for weight and size of weldment but also for centre of gravity CG and how far it is from positioning device.

• COG changes as welder adds material and parts to positioner, so this change must be taken into account.

2.2. Attach weldmentcorrectly:-

•It is important as it is this point where separation would naturally occur.

•Round parts are attached by a three jaw chuck for easy part alignment.

2.3. Use turning rolls for cylinders:-

•Small turning rolls-powered or idler type can rotate a pipe or a vessel to enable, producing an easy circumferential weld.

•Combination of roller type pipe stand and vertical faced table positioners provides stability and safety when a round part is extended outward.

2.4. Keep it flat:-

•Unit is mounted on flat, even surface to prevent it from tipping.

•They should be used to secure positioner to a stable surface to encounter unexpected forces.

2.5. Connect ground current to positioner:-

•Ground current transfers from table and into the chassis which eliminates having to be moved and replaced a welding clamp continuously.

•Without proper grounding electrical parts can be damaged and substandard weld deposits made.

## 3. Latest Trends in Industries

Alignment and positioning equipment are important as they are required in nearly all research and manufacturing processes. The increasing focus on nano-scale engineering has forced engineers and scientists to think about the types of alignment devices which will be required for new and emerging applications. At present, they may choose from two types of state-of-the-art devices; either fixtures or positioners. Fixtures are devices which define a part's fixated orientation and location via a fixed, geometry.

3.1 Drop center gravity positioner:-

The DCG series Positioner provides 2-axis motion, continuous rotation and, ± 180° tilt from the horizontal table position. This configuration of positioner can also be made in a geared elevation version with a third powered axis for elevation. The worktable's surface can be specified at varying distances below the tilt axis, as well as specifying swing radius clearances from the table's rotation axis to the nearest obstruction. Due to the configuration of these models, it is necessary to consult the factory for sizing and capacity requirements. The counter balancing effect of the cantilevered hanger precludes pre-calculated load capacity charts. Since applications require differing hanger lengths and the tables "dropped" distance below the tilt axis, the counterbalancing effect will vary greatly. The load, centre of gravity location, and swing clearance will be required to assist the factory in the selection of the correct model.

Drop-Centre Gravity Features:-

- AC Variable speed drives and motors
- Optional Servo Drives
- Powered ± 180° tilt
- Optional geared elevation models available
- Robotic versions

Fig1. Welding Positioner[8]

3.2 Koike Aronson / Ransome [7] :-

Positioners provide all the advantages of standard fixed height models but also include adjustable elevation to provide ergonomic working heights and improve safety. Gear rack cut into vertical posts and multiple interlocked drive pinions provide the highest degree of safety in the industry. NEMA 12 electrical ground blocks and tapered roller bearings are provided on every unit. Lift-time lubrication and sealed drive units insure many years of trouble free service. Special engineered elevation heights and options are also available. Headstock and Tailstock axes on Koike Aronson Ransome systems are electronically synchronized to prevent work piece / fixture skewing. Both axes are driven by an encoded motor, controlled by a drive with internal PLCcapabilities. Encoder information from both axes is fed back to the Tailstock drive. The Tailstock encoder provides closed-loop position information to the Tailstock drive, which in turn, follows the reference signal from the Headstock encoder. The Headstock drive and motor respond to commands from the operator control pendant (or optionally a supervisory programmable control system). When the Headstock moves, the Tailstock automatically follows, step-for-step, based upon encoder feedback. If any errors are detected internally, or from external devices by either drive, the system will immediately halt to prevent work piece/fixture skewing.

3.3 USA Patents: [5]

Since yesteryears many US scientists have carried out research and review in this manufacturing field of welding fixtures and positioners. These patents revolutionalized the design procedures and advanced its application purposes.

3.3.1. By Edward.V.Cullen

•The present invention relates generally to work positioners. More particularly to that type which are designed and adapted to support and hold metallic structural pieces in different positions.

•A work supporting table which is carried by structure so that it is rotatable about its own centre and is capable of being tilted bodily into different angular positions as well as raised or lowered.

3.3.2. By Edmund Bullock

•According to the invention a jig for use in assembling component parts of composite metal structure comprises a framework of cylindrical form adapted to receive ad secure said component parts in correct relative position for connection with one other and capable of being rotated and titled at the other end.

•This invention relates to the improvement in welding fixtures for supporting a heavy casting or a frame for welding and has a principle object to provide such a fixture, upon which material may be attached without use of crane and which will permit any side of frame or casting.

•Latest trends have proclivity towards positioners of various kinds which makes the operation done quickly and effectively without creating operator assume disadvantages, unsafe or awkward positions.

•Having thus described the invention what I claim as new and desire to secure by Letters Patent is:

i. A work positioner adapted for use in connection with welding and comprising a base with a bracket thereon, a member connected pivotally to the bracket so that it is capable of being tilted in a vertical plane, a work supporting table connected to the member so that it is rotatable about its centre, irreversible gearing between the member and table for rotating the table relatively to said member, and means for readily rendering said gearing inoperative so as to release or free the table for manual rotation.

ii. A work positioner of the character described comprising a base with a bracket thereon, a member connected pivotally to the bracket so that it is capable of being tilted in a vertical plane, a work supporting table connected to the member.

iii. A work positioner comprising a base with a bracket thereon, a member connected pivotally 5 to the bracket so that it is capable of being tilted in a vertical plane, a work supporting table connected to the member so that it is rotatable about its centre, irreversible gearing between the member and the table for rotating the table relatively 0 to the member, including a worm and a worm gear normally in mesh with the worm, and means whereby the worm may be readily disengaged from the worm gear in order to render the gearing inoperative and thus free or release the table for manual rotation.

iv. A work Positioner comprising a base, a bracket carried by the base and embodying a pair of laterally spaced parallel arms extending upwardly and outwardly at an acute angle with respect to the horizontal, a sector shaped member disposed between the arms and having the apex or hub part thereof pivotally connected to the upper extremities of said arms so that it is adapted to tilt in a vertical plane, a work supporting table connected to the member so that it is rotatable about its centre, gearing for tilting the member and table, including a pinion disposed between the lower or inner ends of the arms, and an accurate series of teeth on the periphery of the member and in mesh with said pinion, irreversible gearing between the member and the table for rotating the table relatively to the member, and means for readily rendering the last mentioned gearing inoperative so as to free or release the table for manual rotation.

v. A work positioner comprising a base, a bracket carried by the base and embodying an outwardly and upwardly extending arm, a sector shaped member embodying a chamber therein and having the apex or hub part thereof connected pivotally to the upper extremity of said arm so that it is capable of being tilted in a vertical plane, a work supporting table connected to the member so that it is rotatable about its centre, gearing for tilting the member and table, including a pinion adjacent the lower end of the arm, and an accurate series of teeth on the periphery of the member and in mesh with the pinion, irreversible gearing for rotating the table relatively to the member, including a pair of normally meshing gears in said chamber, and means whereby one of the gears may be readily disengaged from the other gear in order to render the last mentioned gearing inoperative and thus free the table for manual rotation.

vi. A work positioner adapted for use in connection with welding and comprising a base with a bracket thereon, a member embodying a bearing and connected pivotally to the bracket so that it is capable of being tilted in a vertical plane, a work supporting and retaining table connected to the member so that it is rotatable about its centre, irreversible gearing between the member and the table for rotating the table relatively to the member including a drive shaft journal led in the bearing of said member, a worm fixed to the shaft and a worm gear operatively connected to the table and adapted to be driven by the worm in connection with drive of the shaft, said shaft being axially slid able in said bearing so that the worm may be shifted out of engagement with the worm gear when it is desired to render the gearing inoperative and free the table for manual rotation, and releasable means associated with said shaft and adapted to hold the latter against axial displacement when the worm is shifted into engagement with the worm gear.

## 4. Objectives of Welding Fixtures & Positioners Along With Its Advantages

4.1Objective: -

Primary objective of invention is to provide a supporting structure having greater capabilities and not only being used more expediously but also of handling structural assemblies which are bulky to be handled manually.Another objective is to provide a positioner which:

- Occupies small space.
- Both rugged and durable.
- Efficiently and effectively fulfill its intended purpose.
- Capable of handling small as well as large sized work pieces.

- Retain framework in various positions into which it is swung.
- Facilities assembly of components in correct position.

4.2 Advantages:-

- Reduces welder fatigue.
- Increases welder safety.
- Improves weld quality.
- Increases productivity over manually positioning the parts.
- Assists welders in maneuvering and welding large weldments and parts.
- Ensures smooth welding table rotation.
- Faster welding speeds especially for obtaining X-ray quality welds.

## 5. Design Features

The principles of positioning are the same for all weldments, large or small. The base product is affixed to the type or design welding positioner and allows movement by powered mechanical means into the proper weld position and this allows quality welds and faster assembly. Fabricated sub assemblies are added and the entire weldment can be moved to allow easy access to weld joints for easier access for the welder. Properly positioned weldments regardless of the size, reduces welder fatigue. This also increases safety, improves weld quality. By moving the weldment using a welding positioner means and positioning of the welding area so welders are not forced to weld out of position or in an uncomfortable position. Safety is improved when the weldment is fixed to a proper type and design weld positioning device. Cranes, chains, slings and other less safe methods for moving a part will create uncontrolled motion which is a safety hazard. With the proper weld positioner welders do not have to maneuver underneath a possibly heavy weldment. Doing this reduces a safety hazard and the risk of injury from falling sparks, slag, or metal parts.

While many welders are qualified to do overhead and vertical welding, down hand welds often require less training, allowing new welders to produce quality welds. Gravity helps the welder in a downhill weld, resulting in equal legs on fillet welds, smoother bead surface and reduced cleanup and rework times. By combining a positioner with a welding power source and a torch stand, a welder can perform semiautomatic welding that is productive and ergonomically friendly. The positioner holds the part and maneuvers it under a stationary torch. This torch can be fitted with a weaving device to allow oscillation to fill large gaps or V-grooves. Consistent speed and torch position improve the quality of the weld with greater repeatability. By using a communication cable between the integrated positioner and a welding power supply, the operator only needs to signal a start through a foot pedal or a start button, and the welding cycle will continue until the signal is automatically sent that it has completed. This method, typically used on a circumferential weld, can incorporate dwell times to create a puddle and fill the crater. The completed part is removed and another is started. Fabrication welders should keep these rules as paramount when choosing and operating a weld positioner.

When a weldment is a cylindrical, it is eligible to be supported when rotated. Small turning rolls idlers and jack stands with rollers can support the cylinder during rotation. A long pipe or vessel can use these to help overcome the centre of gravity away from the positioner table face plate. Idler rolls are not powered but can be added in series to support these pipes and tanks. Often these are used for a smaller size positioner to do parts that once required larger size weld positioning devices. These do not help offset loads centre of gravity away from the centre of the table out toward the edge of the table or further. The combination of a pipe stand and a vertical-faced table positioner provides stability and safety when a round part is extended outward. The support rollers provide two points of contact and the weight has added support for the centre of gravity. Welding positioning equipment and machines are important that the parts be mounted to a flat and even surface to prevent it from tipping. Most have mounting holes provided that should be used to secure the positioner to prevent tipping when or if it encounters an unexpected force. Some types of positioner have leg extensions to prevent forward tipping. But if the weldment offset load is too much the extensions will not prevent side tipping. Small weld positioners are best used when bolted to the welding table or surface to insure proper grounding and tipping prevention.

For experimental purpose part size given by the customer of 1x1.5m having weight of approximately 1.2 tones the methodology applied is:

5.1 Construction:-

Each weld on any component is welded using a specific welding process with the aid of highly focused electrode shielding gas, large degree of control the welder has over the heat intensity leads to production of very strong and consistent welds [2].

- Base is fabricated and machined and is provided with support pin acting as a pivot having a high clamping pressure of 700 bar for holding parts.
- Base is provided with 4 hydraulic cylinders and 1 main cylinder.
- Gear transmission is contributed by operation of motor through a pinion by gear reduction ratio.
- The major contribution in this process is carried out by fabrication welding system mounted on the base used especially for welding intricate parts like chassis of JCB.
- Sleeve bearings are mounted in order to reduce backlash error and to provide frictionless operation analogous to an escalator.
- There is a power pack unit which includes pumps which drive hydraulic pivots having pressure within the range of 40-50 bars.
- There are two control panels :
    i. Primary: It is used to operate the positioner angle and speed of motor with use of push button or PLC programming.
    ii. Secondary: It is used to vary the clamping pressure of the fixtures mounted on the base table.
- In order to achieve flexibility in operation clamps slide on guide way having a lock-pin arrangement.
- Hinge pin plays a pivotal role in fixing s hydraulic cylinder with the base of the working cylinder.
- In order to fulfill the advantages stated in the above context manufacturing is carried out mainly by using a Vertical Machining Centre (VMC) performing several operations like milling, turning, boring and it is more advanced than CNC machines.

5.2 Material:

- The fabrication System mounted on the base is made up of mild steel.
- For hard parts which are prone to inducing friction is made up of alloy steel grade EN-19 having high tensile strength, good ductility and shock resisting properties.
- Pins are made up of 20MnCr5 which are toughened and case hardened for smooth operation.

Fig2. Fixture Assembly[8]

5.3 Procedure

As a result of complex alignment and positioning equipment are important as they are required in nearly all research andmanufacturing processes [1]. The increasing focus on nano-scale engineering has forced engineers andscientists to think about the types of alignment devices which will be required for new and emergingapplications. At present, they may choose from two types of state-of-the-art devices; either fixtures or positioners. Fixtures are devices which define a part's fixated orientation and location via a fixed geometry.

- Material selection.
- Analysis of selected material on computer aided software's.
- Prototype design.
- Performing tests on the prototype.
- Calculating Centre of Gravity based on the test reports.
- Gear Box design for speed variations.
- Pressure calculations required to be supplied by the hydraulic cylinders for clamping operation.

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## Conclusion

Conclusion is drawn on the basis of the information collected on each aspect of our project. It leads to a belief that if applied will create an even better machine than we have designed. The process of conducting operations related to welding fixtures and positioners helps in gaining a deeper understanding as well as effective project process. The prototype construction proves fruitful in analyzing the process for its potential as a finished product.In today's market all large manufacturers are automating as much of their production line as possible. Automated processes have been in high demand extensively in past two decades but there is still room for improvement. Welding fixtures closes the gap in the engineering of automated fixture mechanism. From finding a resource for research material to design updates of the part causes the task of accurately prototyping the real design difficult. It is important that the design satisfies all of the functional requirements and design parameters which were outlined at the start of the project. In order to meet the requirements of the fixture customization is done by making the clamping system very practical for various sizes and geometries. A few other considerations for calculations that would ultimately improve the quality of the welding fixture are stress analysis and cost benefit analysis. Stress analysis and friction analysis would both help in the selection of material to be used for each part of the machine. Thorough stress calculations could not be done without knowledge of the material being used for each part, because of different materials physical and mechanical properties. By also knowing the material selection a cost benefit analysis could be conducted to determine how cost effective the product is. All of these calculations would greatly add to the significance of the research already conducted.

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