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Laser Beam Diameter, and Energy Concentration

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In my last article I wrote about the various adjustable parameters, and the effects of changing those parameters. In this article I hope to explain, in better detail, how the energy of the laser beam is focused. I will likely be referring to some terms that may be better understood, by reading my previous article.

The focus of the beam is expressed by the diameter of the beam. The diameter is the circular area of the beam that the selected energy is concentrated into. The concentration of the beam's selected energy plays one of the most major roles in selecting the correct parameters to complete a particular welding job. If you recall, Voltage and Pulse Duration are the two adjustable parameters that determine how much total energy is delivered in one laser pulse. For the selection of the correct welding parameters for a particular job, I will often determine an adequate total energy, at a given diameter, by a short trial and error method of fine tuning the Voltage and Pulse Duration, (always making the error on the side of caution by starting low and adjusting up). Once the total energy shows adequate penetration and melting, I can usually complete all remaining phases of the job by changing only the Beam Diameter to achieve the correct results for each particular phase of that job. The effect that adjustable Beam Diameter plays in choosing the correct parameters and completing a welding job cannot be overstated.

The machine operator, (person doing the welding), should know the physical outline of the beam and what the basic energy distribution is like at various plains, or (Beam Diameters) in the beam's path. The attached illustration shows a non-scale drawing of what the beam looks like as it is being focused into the working compartment by the Objective Lens. The main point of reference for our discussion is the Focal Plain. The Focal Plain is an invisible plain that runs perpendicular to the vertical center of the beam; originating at a place where the beam is focused to its narrowest diameter when the smallest Beam Diameter has been selected, and extending to all points outward on that plain. Different makers of Laser Welders may reference their Beam Diameter differently. Figure one's Beam Diameter is referenced according to the Rofin-Baasel machine, as that is what I am most familiar with. The attached illustration shows an adjustable Beam Diameter with a range between 0.2 mm, (smallest), up to 2.0 mm, (largest). The selected Beam Diameter is expressed as arbitrary numbers that range from 0-42 because there are 42, individual, adjustable, increments that correspond to the pictured Beam Diameter. Since Beam Diameter plays such a large role in selecting the correct parameters to complete a job, then it should make sense to the reader, that the larger the range of diameter, from smallest to largest, and the more selectable increments within that range, gives the operator more control over how the energy is concentrated and delivered.

The Focal Plain has its name for two reasons. The first reason is: When the Beam Diameter is adjusted to 0, the smallest diameter of the beam is located on the Focal Plain. Therefore, the beams focus, (or diameter), is referenced at the focal plain. As the Beam Diameter is increased from 0 to a larger diameter the smallest diameter of the beam moves below the Focal Plain leaving a larger selected beam diameter at the Focal Plain. Therefore, the Focal Plain is the constant reference that the operator must be using to hold the piece being welded. That leads to the second reason for the term, Focal Plain: The focus of the operators viewing system must be adjusted for each individual operator's eye sight. Since the Focal Plain is the reference point for setting the Beam Diameter, it is important for the operator to view the Focal Plain in maximum focus according to the his or her individual eye sight. If the operator has adjusted the machines viewing system correctly for his or her eyes, then the piece being welded will always be in focus and held on the Focal Plain.

By referring to my previous article you will see that adjustment of Beam Diameter does not effect the total energy being delivered, but does effect how the total selected energy is concentrated. The consistent effects of the selected energy greatly depends upon the operators ability to see, and hold the work at the Focal Plain. By doing so, a consistent energy concentration, from pulse to pulse, is used. If the viewing system focus is adjusted differently, for a given operator, every time the machine is used by that operator, then that operator will not have a consistent reference of what results from a specific parameter setting, because a different energy concentration is being used. This is because the operator is not holding the piece at a consistent point in space, (namely, the Focal Plain), and the operator is, mistakenly, using various Beam Diameters. In order to have consistent results that lead to learning the correct and consistent parameter effects, one must learn how to adjust the viewing system to correctly focus the Focal Plain to his or her individual eyes. One must also hold the piece in focus, on the Focal Plain, while welding. When choosing a viewing system for your machine, it is extremely important to choose a system that allows the operator to adjust the viewing system focus for each operators individual eye sight. Otherwise, the relationship of all parameters will be difficult for each operator to learn because they are not being referenced consistently and correctly at the Focal Plain. In addition, the full effect of energy distribution within the beam may not be available to the operator if the viewing system is not focused correctly.

The illustration shows laser beam that keeps its diameter for a nominal distance above and below the focal plain. This is known as the Sweet Spot. This feature has many advantages that I could talk about forever, but the one advantage that relates to this discussion is that the energy concentration within the Sweet Spot stays consistent above and below the focal plain. The Sweet Spot feature allows the operator some space to work above and below the focal plain without changing the energy concentration, or beam diameter. Because of jewelry's design features and curves it needs to be moved into different angles while welding, making it almost always necessary to hold jewelry in the hands while welding. Since human hands and human eyes are subject to error while focusing, the constant beam diameter above and below the Focal Plain will deliver consistent results within this area that is known as, "The Sweet Spot".

By understanding the physical outline of the beam, and how it relates to energy concentration at the focal plain the operator can gain a better understanding of how all of the machines adjustable parameters inter-relate, allowing the operator to accomplish more with the machine.

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