Development of a numerical model and the stability analysis of dynamic keyhole in deep penetration laser welding process using the phase-field method – SERB

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The quality of the joint in a keyhole mode laser welding process depends on the stability of the keyhole, which is dynamic in nature, and the complex problem is represented by multi-phase and multi-physics interactions at the onset of the keyhole formation. The keyhole formation is associated with common welding defects such as humping, porosity, and spatter formation. It is practically significant to understand the cause of defects and how to improve the weld quality. The major challenge for the keyhole formation is the interface tracking to define the shape and the free surface of the keyhole.

The objective of the proposal is to introduce the phase-field model for the interface tracking along with the solution of mass, momentum, energy and species concentration equations in a keyhole mode laser welding process as well as to predict the defect formation. The secondary objective is the stability analysis of the keyhole in terms of the amplitude of the depth and their frequency.

- ❖ A 3D finite element based numerical model using FORTRAN is proposed here. Practically, it is important to identify the process parameters, which brings the stability criteria of the keyhole formation. Overall, the keyhole profile, strategy of solution algorithm, prediction of defects and stability analysis as a function of input parameters in a deep penetration laser welding process are the possible outcome from the proposed work.

- ✓ Detail review of existing literature in the aspect of the keyhole model (both analytical, semi-analytical, and numerical), and the mathematical criteria for the stability of the keyhole are performed. A review of the application of the phase-field model for sharp interface tracking problems are also performed that is aligned to the dynamic keyhole wall between liquid and gaseous phases.
- ✓ Overall, the establishment of the theoretical formulation associated with keyhole formation and their stability analysis is continuing at this stage.