OBJECTIVE: Accurately determine the inclusion content of steel bar stock, gear, and bearing components in finished or semi-finished states by non-destructive means i.e., without the use of traditional destructive method of cross-sectioned specimens.

DESCRIPTION: The Naval aviation community, as owner and operator of aerospace systems, continuously seeks improvement in the manufacturing arena. The Navy occasionally faces issues with inclusions in aerospace components made from high-grade steel. The Navy seeks an innovative, cost-effective, accurate, preferably hand-held, non-destructive technology that would allow inspection of high-grade steel components for inclusion content without destroying the material. This would increase the possibility of identifying non-conforming material and parts early in the production process, minimizing the work expended. For components, the proposer should create a focused method to identify inclusions in critical targeted areas of the load carrying components, which would result in a decrease in the cost to the Government or original equipment manufacturers (OEMs) by removing the need to inspect suspect components by destroying potential conforming components. The innovative technology should be capable of measuring and determining the position of the inclusion content of steel material by non-destructive means. Accuracy targets are requested in the 0.001” particle size with full volume inspection of the material. Maximum material thickness is expected to be no greater than 14” round steel bar stock. Particle location determination is requested within the inspected material. The ability to inspect complex geometries, like gear teeth, is required. The information provided to the operator when using the method should be instantaneous in order to provide feedback on the specific targeted area of material. This method must have the ability to be used in environments including steel manufacturing sites, component production sites and repair facilities. If not possible to be hand-held it will need to be portable enough to allow use on installed components or components outside of stationary or lab-type environments.

Current destructive methods start with a polished sample coupon of material followed by a microscopic visual inspection, or a computer-aided surface inspection. Neither method reviews the material used in the component itself. Only a small section of material is reviewed relative to the component produced. Existing non-destructive methods, like eddy current or CT scan, do not provide the fidelity required to categorize the material to the level desired. The depth of penetration and sizes of particles that can be detected limit the usefulness of the current non-destructive inspection (NDI) technology.

Although not required, it is highly recommended to work in coordination with the OEM to ensure proper design and to facilitate transition of the final technology.

PHASE I: Design and develop a concept for a non-destructive technology allowing a determination of inclusion content within steel bar stock or components. Conduct a breadboard demonstration of the concept. Include size, distribution, and location of inclusions within the bar stock or within identifiable component regions - all desired characteristics for determination - plus inclusion material identification, which is a secondary goal for determination. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop and demonstrate a prototype with the capability of the non-destructive detection of inclusions with blind steel samples. Ensure that the demonstration includes production size and grade steel stock. For steel components, demonstrate with in-process (partially finished) and post-production components. Aim for inclusion sizes down to 0.001”. Meet the requirement for rapid, near instantaneous analysis of the steel material in the intended environments, which are steel manufacturing sites, component production sites, and repair facilities.

PHASE III DUAL-USE APPLICATIONS: Perform final testing that would include on the ground evaluation in fleet/repair/production environments. Transition a fleet ready device or a commercial offering on an inspection device. The intent is to provide higher levels of steel cleanliness verification. With verification of the cleanliness of steel material and components, there is the potential for either longer duration of use with existing designs or higher power density components.

Successful technology development would benefit steel manufacturing, engine/transmission component manufacturers, and
construction industries.

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KEYWORDS: Inclusion; Steel; Inspection; Material Cleanliness; Non-Destructive Detection; Sub-Surface