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Engineering Design Considerations for a Laser Direct-Drive Fusion Reactor

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Focused Energy is working on a conceptual design of a Fusion Energy Reactor using laser direct-drive inertial confinement fusion. The work has started with the goal to identify the best options for the system with maximum benefit of the present knowledge of materials and manufacturing of the different components being available in the desired time for a Fusion Pilot Plant (FPP) and a First-of-a-kind (FOAK) facility.

Among the different challenges, a key component is that of the first wall (FW) and its lifetime, which depends on the design of the protection layer and the choice of materials (W, W alloy, others). In several Laser Fusion projects, when considering the influx of ions, debris, x-rays, and the large thermal heat load generated in the FW materials, W has been a rational and main option; however, the implantation of neutral gas atoms (He, H) appears today as the main problem for extending its use to long lifetime. A new assessment was needed depending on the required lifetime and the time-space irradiation profiles. Options already proposed and some tested for Laser Fusion, such as carbon-based materials, SiC, other carbides and oxides, and nanocolumnar, foams and nanoneedles based in W or High Entropy Alloys appear on the horizon and are being investigated.

The design of the breeder blanket (BB) is another key component. The design starts with a full review of the options from liquid breeder-coolant, liquid-gas breeder/coolant, or ceramic breeder with gas cooling. A key parameter is that of the tritium breeding ratio (TBR), which is considered a key neutronic factor to maintain an adequate value with simple on-time maintenance. This work will give several conclusions in designing our BB, the materials, and the parameters. TBR is an important parameter affecting the design very much, the Li enrichment, and the potential neutron multiplier. Another key aspect is that of available systems for an efficient tritium extraction and considerations of those systems will be presented. Finally, the damage in reduced activation materials such as ferritic-martensitic materials, both oxide dispersion strength (ODS) or EUROFER, could be a concern, but operational engineering procedure could change the perspective.

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