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Optimization of green machining of ZrO2 via a simple and small CNC mill

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Machining of sintered ceramics is a slow, costly process and is therefore not suitable for the production of parts with complex geometry. Therefore the machining of green or partially sintered (bisque) bodies becomes a highly interesting alternative. Recent advances in cad/cam technology have enabled the feasibility of green machining for the production of ceramics on both, large and custom scale. Characteristics of the green or partially sintered ceramic body (mechanical strength, hardness, density, etc.) define its machinability. At the same time the machining parameters (feed rate, depth of cut, and tool – rotation, material and geometry) can optimize this machinability, producing a low roughness and crack-free machined surfaces, and preventing chipping of the edges. In this work, isostatically pressed zirconia ceramics, green or partially sintered (800 to 1000 °C) were machined, with and without cooling liquid, in a simple and low cost CNC milling machine. Parameters such as the rotation, geometry and grain size of diamond impregnated mild steel tool, the feed rate and the depth of cut were varied and the design of experiments (DOE) method was applied to determine the influence of these parameters in the roughness of the machined surface, the formation of microcracks, the integrity of the edges, and the wear of tool. It was verified the benefit of the cooling in the wear of the tool and also in the finishing of the green and sintered surface. It was possible to reach a set of conditions related to the characteristics of the ceramic bodies and to the milling parameters that allowed obtaining surfaces with low roughness (Ra< 1.2 micron), free of cracks and without chipping of the edges.