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The Origin of the Out-of-Dry-Dock Drag Penalty of a Ship

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ABSTRACT

In a separate abstract submitted to this session, the authors have demonstrated, through field experiments, that a 'clean' ship (fresh from dry-dock) experiences a friction drag that is already 26% higher than that of a hydrodynamically smooth hull of equivalent length. With the advent of more effective anti-fouling coatings, and subsequent implementation of longer dry-docking cycles, it is this fresh from dry-dock condition that best describes an increasing portion of the operational cycle (between dry-docks) and hence plays a large part in setting the hull drag penalty on the global fleet. This in turn suggests that tackling the baseline roughness existing on the 'clean' vessel may be a viable pathway to reducing emissions of the global fleet.

However, before such an approach could be adopted, it is necessary to determine which aspect of the hull state contributes to this initial increase in hydrodynamic resistance. This present work investigates the drag of the underlying paint roughness. The surfaces being tested are reproductions from the field test vessel, the Sinar Morotai (owned by Pt. Samudera Indonesia). During dry-docking, imprints of the hull were taken immediately after cleaning and re-coating using polyvinylsiloxane (PVS), capturing the orange-peel surface condition, as shown in figure 1(a). These were subsequently scanned using a Nanovea chromatic light profilometer and inverted. Figure 1(b) depicts a height map of one such location along with the key statistics of the surface. For wind-tunnel testing, to match the roughness Reynolds number ($k^+ = ku_\tau/\nu$) to the operational conditions of the ship, the surface was geometrically scaled by a factor of 5 and then tessellated and machined to cover the $4 \times 0.9\text{m}^2$ test surface of the wind-tunnel facility, as shown in figure 1(c). A cantilever-type drag balance is used to measure the wall friction drag. These experiments demonstrate that the underlying paint surface finish causes a drag penalty of 13 - 16%, approximately 10% less that the 26% drag penalty measured from the field experiments. This discrepancy might suggest that docking-blocks or weld seam roughness also make a contribution to the observed baseline penalty, which is the subject of ongoing investigation.

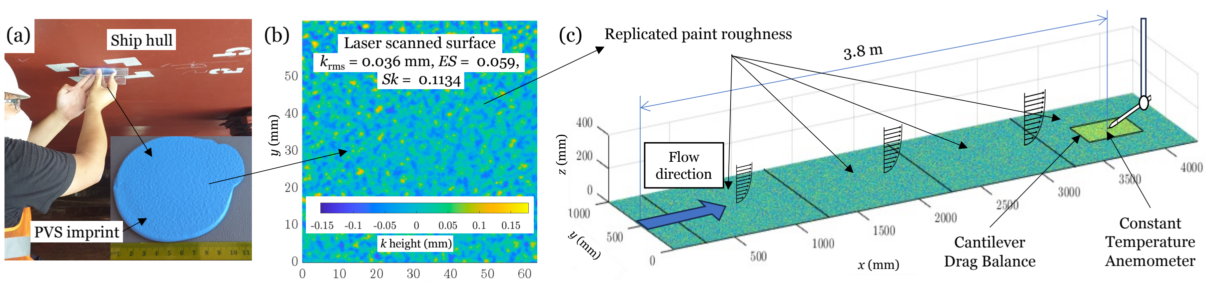

Figure 1: (a) Taking surface imprints. (b) Height map showing one of the processed imprints. (c) Laboratory experiment.