'€1 million per micron' – assessing the quality of superyacht finishes

Alan Guy, director of technology at coatings specialist and engineering consultant Safinah Group, considers some of the challenges related to paint finishes on superyachts – and in particular, how best to mitigate the 'orange peel' effect

Figure 1: Example of the effect of 'orange peel'

The aesthetic appearance of a superyacht is judged against several criteria, some of which are measured instrumentally whilst others can be assessed visually. Despite the complexity of the shapes and the larger areas to which the topcoat is applied, the standard of finish expected is most often of a higher standard than that of an expensive luxury car.

Several authors have discussed the factors that when combined contribute to a 'good' finish [1]. In Safinah's experience, assuming that the paint finish is free of other defects such as sags, runs, excessive dust inclusions and fisheyes, etc, there is rarely a problem with gloss levels. The aspect that causes most debate is the residual structure, or 'waviness', known as 'orange peel'. Reflections from 'peely' surfaces appear 'pixelated', as shown in Figure 1.

This article outlines some of the factors affecting the image quality, and what steps can be taken to mitigate these effects.

An acceptable standard

Determining an acceptable standard of finish is normally a joint decision between the various parties involved. It can involve a visual appraisal of a reference panel, which may be a part of the yacht or a separate stand-alone mock-up. Using this approach, instrumental readings taken from the reference area are then used as the standard by which the rest of the paintwork is judged.

Alternatively, a set of acceptance criteria may be agreed based on experience with the proviso that the visual appearance overrides the instrumental readings.

When using a reference panel, viewing distance is important. The various complex structures that make up 'orange peel' on the paint surface become visually apparent at different distances due to the resolving power of the human eye. For example, at a distance of 40cm, structure sizes between 0.3-10mm can be seen, while at a distance of 3m, only larger structures of 3-30mm are visible. It must be noted that, typically, structures smaller than 0.3mm are mainly responsible for the image-forming quality of a surface, also referred to as the 'Distinctiveness Of Image' (DOI).

DOI is not sensitive to low amounts of 'orange peel' on high quality surfaces. An alternative measurement, Reflected Image Quality (RIQ), may be used as it has a more proportionate response to 'orange peel' on a wider range of surface finishes.

The instruments used to measure the surface structure analyse the reflected light and use mathematical filters to transform the raw data into more easily understood numbers.

'Orange peel' formation

'Orange peel' arises from the spray application process and is present to different extents in primers, build coats and antifoulings as well as topcoats. Generally, the higher the build, or 'hold up', the greater the 'orange peel'.

Topcoat application on superyachts is generally carried out by conventional or, now increasingly, by electrostatic spray. These techniques use high pressure air to atomise a jet of liquid paint into small droplets, a few tens of microns in diameter.

The paint droplets are propelled towards the substrate where they land and coalesce, eventually forming a coherent film. After coalescence, surface tension effects begin to flatten and level the paint film, as illustrated in Figure 2. At the same time solvent evaporation and reaction between the components of the paint increase the viscosity which works against the levelling forces. Eventually these forces come into balance leaving the 'wavy' structure in the surface perceived as 'orange peel'. The 'orange peel' in the paint can be thought of as an overlay of several structures with different wavelengths and amplitudes.

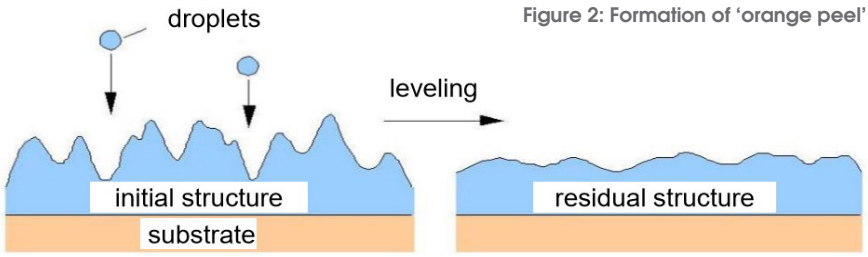

Figure 2: Formation of 'orange peel'

Incident light is reflected at different angles from these surface structures.

Paint formulation

The extent of the residual structure is dependent on the formulation of the paint, application conditions and process.

Paint formulations are complex and must be optimised for many different aspects such as manufacturing processes, storage stability, application characteristics, cure times and dry film properties as well as regulatory requirements. It is therefore, at times, a very complex and difficult process.

The resin system and pigments provide many of the desired properties such as drying times and durability. Other aspects of the formulation are optimised using various additives. One example of the use of additives is in 'hammer finish' paints. The distinctive appearance of the film is in fact a controlled defect produced by the incorporation of a silicone additive that migrates to the surface of the paint.

Additives that produce 'hold up' are called thixotropes, whereas flow and levelling aids produce the desired flat film. When correctly dispersed, thixotropes produce a hydrogen-bonded structure that gives the paint a high viscosity under conditions of low shear – on a vertical surface, the low shear force is gravity. At the same time, the thixotrope should not affect the paint viscosity under the high shear conditions found at the tip of the spray gun during application.

Flow and levelling aids are slightly incompatible and migrate to the surface of the wet paint film, reducing and equalising the surface tension at the air/paint interface thereby flattening the film. This process is facilitated by a low paint viscosity.

One of the most difficult problems facing a formulator of yacht finishes is how to balance the opposing requirements of high viscosity to prevent sagging, whilst at the same time minimising viscosity to ensure sufficient flow and levelling to produce a smooth film.

After a formulation has been optimised, it is extensively trialled to confirm its application properties and performance before commercial release.

Control during application

Once the formulation is finalised, the burden of producing the best possible finish falls to the shipyard to provide the specified environmental conditions, and to the paint applicators to use their skill and expertise to produce a film with as little surface structure as possible.

After the paint leaves the spray gun, there is little an applicator can do to rectify any problems or imperfections without major re-work, expense, and delays. In general, there are four main issues which affect the quality of the application of any topcoat:

1. Environment;
2. People;
3. Process;
4. Equipment.

Shipyards should, ideally, control the environmental conditions to ensure that the temperature and relative humidity limits specified by the paint manufacturer are met.

Paint applicators should also control their personnel to make sure they are properly trained and understand their processes. There can be issues however with the understanding and use of spray equipment. There are numerous variables when using spray equipment, from air pressures, airline lengths and bore, spray gun tips and needles and paint atomisation, all of which must be considered when it comes to producing as close to the perfect finish as possible with minimal 'orange peel'.

Overall cost

After application, the final topcoat dry film thickness is typically in the range of 40-50microns (approximately the thickness of a human hair) but it is the top few microns, where the 'orange peel' is present, that are the most important when it comes to acceptability.

'Orange peel' has a typical peak to trough height, or amplitude, of around 2-4microns. Hence, a flatter surface with an amplitude of approximately 2microns or less is typical of an acceptable finish. By contrast, an often-unacceptable finish would have a typical amplitude of 4microns and above. In this case, the only way to rectify this is to sand and respray the affected areas, ideally while the superyacht is still in the shipyard with all the staging, tenting and equipment already in place.

However, it is not unheard of when, for operational reasons, the newly painted yacht leaves the yard with an unacceptable finish and with the commitment from the shipyard to repaint the substandard areas. In situations where considerable remedial work is required, possibly a full repaint, the overall cost - including possible loss of charter revenue, yard and docking costs, removal of fittings and application, etc, could easily reach in excess of €2 million – all because of an extra 2microns.

Divide one by the other and it comes to €1 million per micron.

Summary

There are of course assumptions in the reasoning above and, hence, it could be perceived as a worst-case scenario. However, it serves to illustrate how demanding the standards of finish are in the superyacht industry, how difficult it can be to get the best out of the paint and meet those standards, and in particular, how important it is to get things right first time.

While it is up to the paint companies to produce the best formulation, once this is finalised the focus moves to application. The key to getting the best out of the paint is expert management, monitoring of the conditions and provision of guidance, where needed, during application. ***SBI***

Reference

1. KATTAN, R. *Assessing yacht finishes*, International Conference on Design, Construction and Operation of Super and Mega Yachts, The Royal Institution of Naval Architects, Genoa, Italy, 1st and 2nd April 2009. ISBN: 978-1-905040-56-8