From the Lab

White Papers from Wesbond Corporation

What are Wetting Agents Good For?

--Wes Jones, Wesbond Corporation

Wesbond Corporation is the leading supplier to the refractory fiber vacuum-forming industry. We research all aspects of fiber bonding, from different fibers to different binders to post-treatment with additives. We publish the results so everyone in the industry can benefit from our research. We respect the confidentiality of our customers and publish only with their consent.

Wetting agents, or surfactants, or surface active agents, are chemicals that reduce the surface tension of a liquid. This allows the liquid to flow more easily and penetrate more effectively. There are three main types of surfactants: anionic, cationic, and non-ionic; they are distinguished by their electrical charge. Anionic (negatively-charged) and non-ionic are the most common. Surfactants are the main ingredient in detergents. It is a rule of thumb in the business that if you want foaming you use anionics, if you want penetration you use non-ionics, and if you want both, you use a mixture.

Introduction

A customer approached Wesbond with a need to rigidize a Celotex-type board for use in a hot-top application. They needed the board to be harder, stronger, and more refractory. The customer knew that infiltration with colloidal silica was the standard way to accomplish this, but had had no success. Wesbond agreed to investigate this board to see if infiltration with colloidal silica was possible. We jointly decided that the criteria for evaluation were weight pick-up after drying (to test the efficacy of the wetting agent), and surface hardness after drying (to test the efficacy of the rigidizer).

The samples were a low-density board which appeared to be a cellulose fiber/perlite board bonded with something like asphalt. The boards were 12” by 12” and 1” (25 mm) thick. They were completely impervious; water ran off them, and after immersing they came out completely dry.

Approach

It was decided to test the effectiveness of Wesbond PS9400W wetting agent in infiltration. PS9400W is a nonionic surfactant that is compatible with both high pH rigidizers such as colloidal silica, and low pH rigidizers such as colloidal alumina. The boards would be sectioned for easier handling, infiltrated with colloidal silica containing the wetting agent at various contentrations. The samples would be evaluated based on 1) weight pick-up after drying; and 2) hardness measured on the surface and through the interior of a cut sample. Wesbond also decided to evaluate 3) hardness through the thickness of the board to study penetration of the rigidizer.

Experimental Procedure

The as-supplied Celotex boards were approximately 12” by 12” by 25 mm thick. Of the two flat surfaces, one was slightly darker, and was arbitrarily labeled “Top”; this was maintained throughout the experiments. The boards were cut into 3” by 3” by 25 mm pieces with a power saw. Samples were immersed in Levasil FO2040 colloidal silica rigidizer. Various concentrations of the rigidizer were tested. Wesbond PS9400W wetting agent was added to increase penetration of the colloidal silica.

The first experiment was used to evaluate the absorption of the boards. Each 3” x 3” was cut into 3 sections, each 1” x 3”. Each piece was weighed dry, then infiltrated with colloidal silica by immersing it for 30 seconds. The wet weight was recorded, the pieces were dried at 250°F and then the final weight recorded. Wet and dry pick-up was calculated. Hardness was measured on the top, bottom, and side faces using a Shore “O” durometer, and the results averaged.

The second experiment measured the hardness of the rigidized boards through the thickness. Several 3” x 3” pieces were cut, weighed and measured for volume and density, then immersed in selected colloidal silica compositions for 30 seconds. The wet and subsequent dry weights were used to measure silica pickup. Hardness was measured on the top and bottom faces. The pieces were cut through and hardness measured at regular intervals throughout the thickness of the piece.

Results

Effect of wetting agent

Refer to Fig. 1 below. Three concentrations of Levasil FO2040 were used to infiltrate the boards. Note that with no wetting agent there is almost zero pickup of colloidal silica. The dry pick-up weights increase rapidly with surfactant addition and seem to reach a plateau between 0.2 and 0.3 weight percent. (Note that 1 gram of wetting agent added to 1000 grams of colloidal silica equals 0.1 weight percent).

Note also that higher concentrations of colloidal silica mean greater weight pick-up.

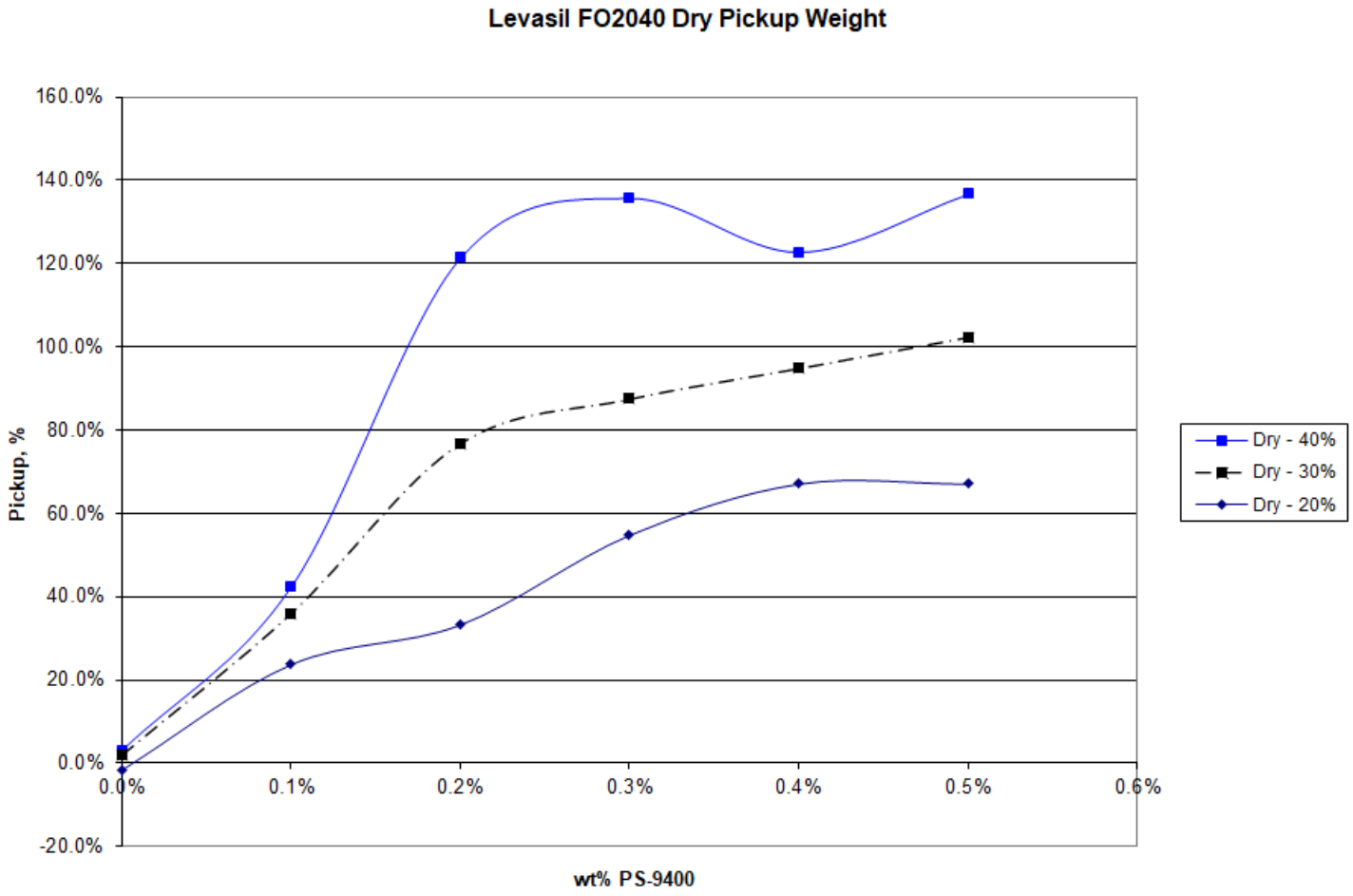

Figure 1 Dry weight pickup of colloidal silica as a function of wetting agent concentration for three concentrations of colloidal silica. In all cases the immersion time was 30 seconds.

Hardness after Infiltration

Refer to Fig. 2 below. A durometer was used to measure the surface hardness. Readings were averaged over all faces of the infiltrated samples, and increased rapidly from about 55 to over 80 for all but the most dilute rigidizer.

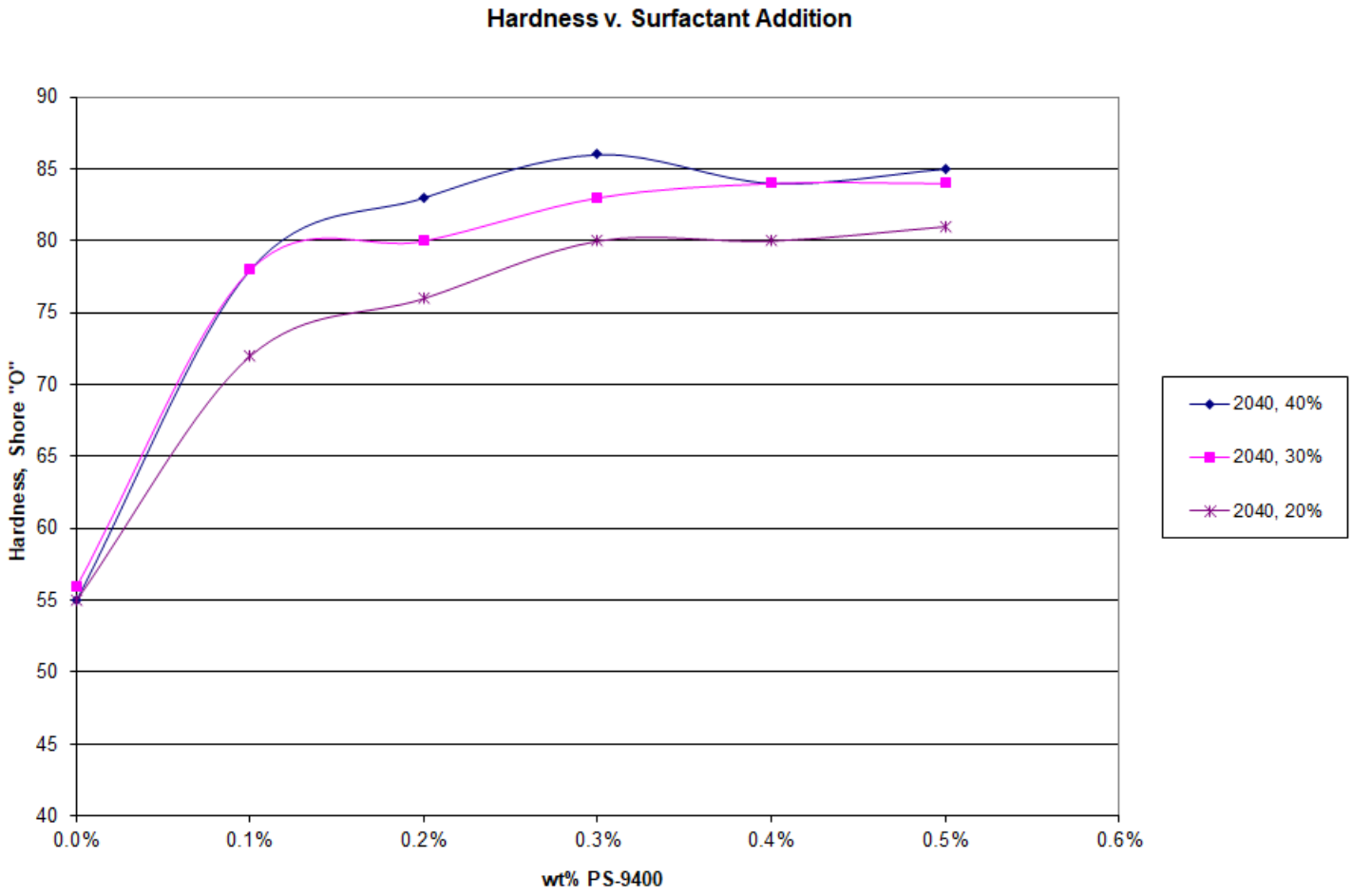

Figure 2 Shore “O” surface hardness as a function of wetting agent addition three concentrations of Levasil FO2040. In all cases the immersion time was 30 seconds.

Internal Hardness after Infiltration

Refer to Fig. 3 below. The samples were immersed in the rigidizer at 40% (“2040-1”) or 30% (“2030-1”) concentration for 30 seconds; the wetting agent level was 0.2%. Previous work had shown that complete saturation of the samples was achieved in 30 seconds. Several of the 3” x 3” samples were sectioned and the hardness measured at various depths. In the figure “0” represents the top of the sample, and “25” the bottom. It is apparent that most of the colloidal silica has dried within the first 5 mm of both surfaces. This migration of rigidizer is well-known in the vacuum-forming business.

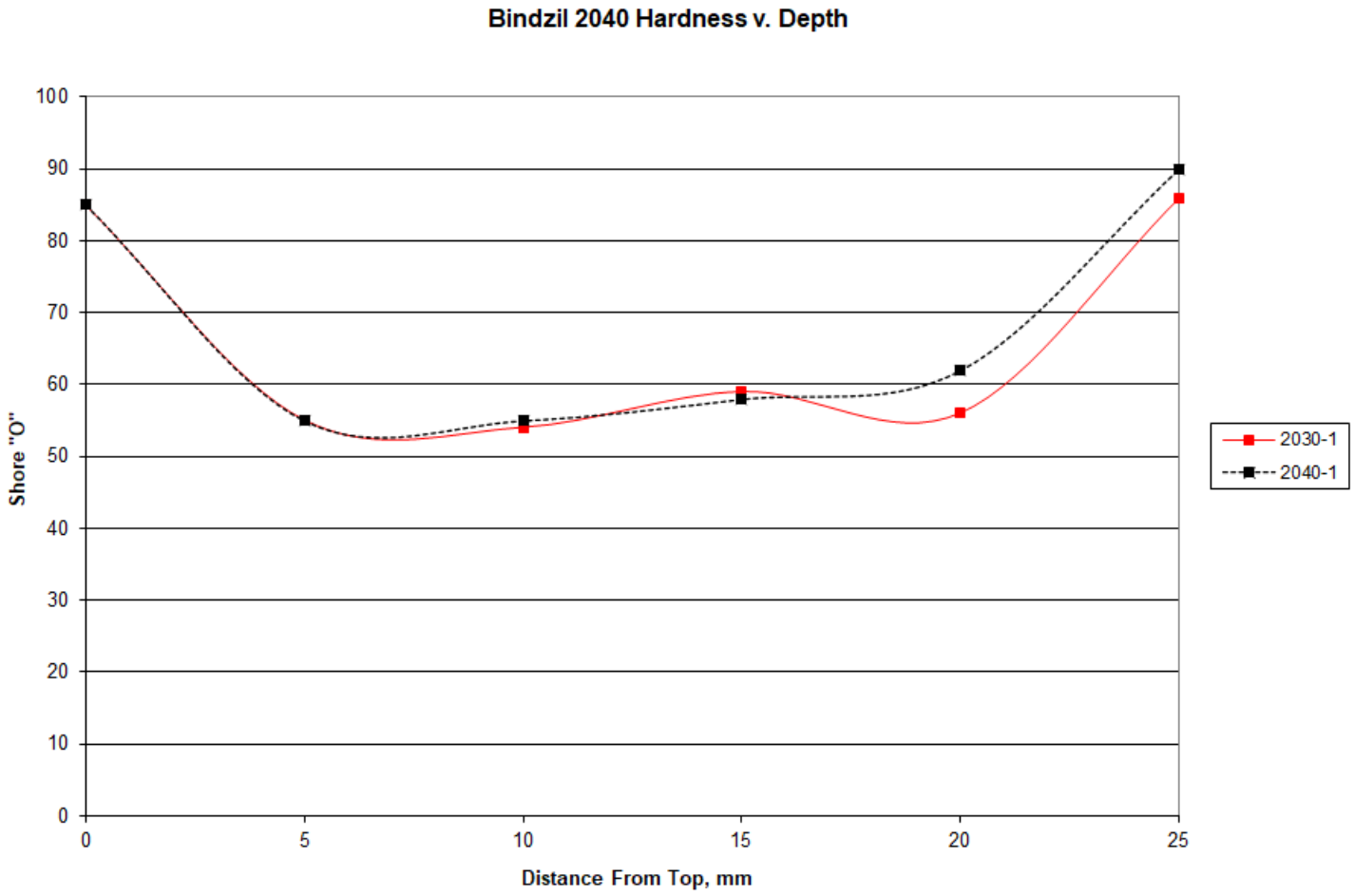

Figure 3 Internal hardness after infiltration with Levasil FO2040. Sample 2040-1 used 40% colloidal silica; 2030-1 used 30%. In both cases the surfactant concentration was 0.2% and the immersion time was 30 seconds.

Discussion and Conclusions

It is clear that wetting agents can improve penetration of rigidizers. As expected, the surface hardness mirrors the amount of colloidal silica retained in the samples.

It is also clear that the rigidizing effect is mostly a surface effect. Migration of colloidal silica back to the surface during drying is a well-known effect in the rigidizing business. While a discussion of this effect it is beyond the scope of this paper, several processes and tactics have been used to reduce this migration. Microwave drying, gelation, freezing, and freeze-drying are just a few.

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