Transactions of the Materials Research Society of Japan. Vol. 20

Development of high efficiency steam extraction system

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Abstract

We have paid much attention to developing an extraction system which should be applied for an industrial production of essential wood oil. We demonstrate a developed steam extraction systm by means of pressure swing extraction method (SPE) with a high efficiency and a short extraction time.

It was found that a total amount of extraction was larger in the SPE with a higher extraction rate in early stage than in an atmospheric steam distillation.

1. INTRODUCTION

A grate deal of literature shows us that there existed essential wood-oil extraction devices from HIBA,HINOKI and KUROMOJI by using steam extraction methods. However,most of them were so antique and small that they were only limited in an subsidiary use of forest industry.

Hence we have studied on developing a system which enables us the extraction of essential oil from woods applied for an industrialized business.Our first approach was carried out to improve the conventional steam extraction device and it was completed to obtain data useful for the industrial scale model. The characteristic data of extraction for designing were accumulated toward typical woods of HIBA,HINOKI and SUGI.

We hereby represent a further study on developing steam extraction device by means of pressure swing extraction(SPE) method for improving an extraction efficiency and for shortening time.

2. EXPERIMENTAL SET UP

2.1 Equipment

A schematic diagram of an experimental set up is shown in Fig.1 and Photo.1 shows a photograph of the test equipment. The SPE system is consisted of a one-through boiler(1), SUS made pressure vessels for

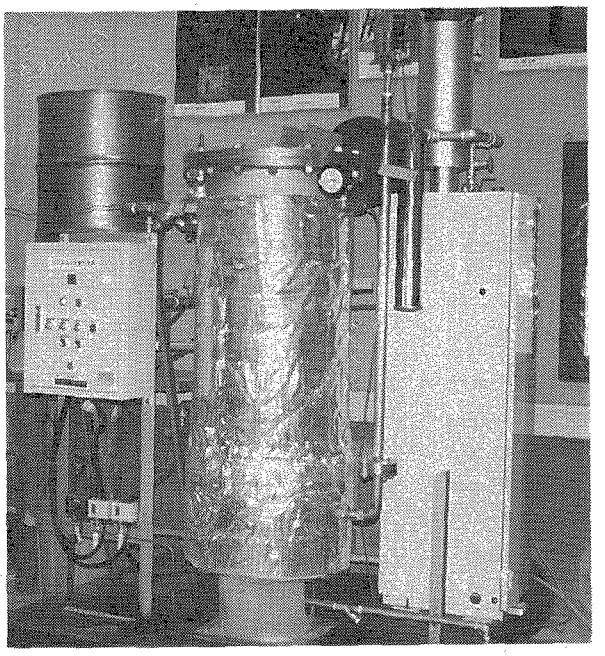

Photo 1. View of experimental set up.

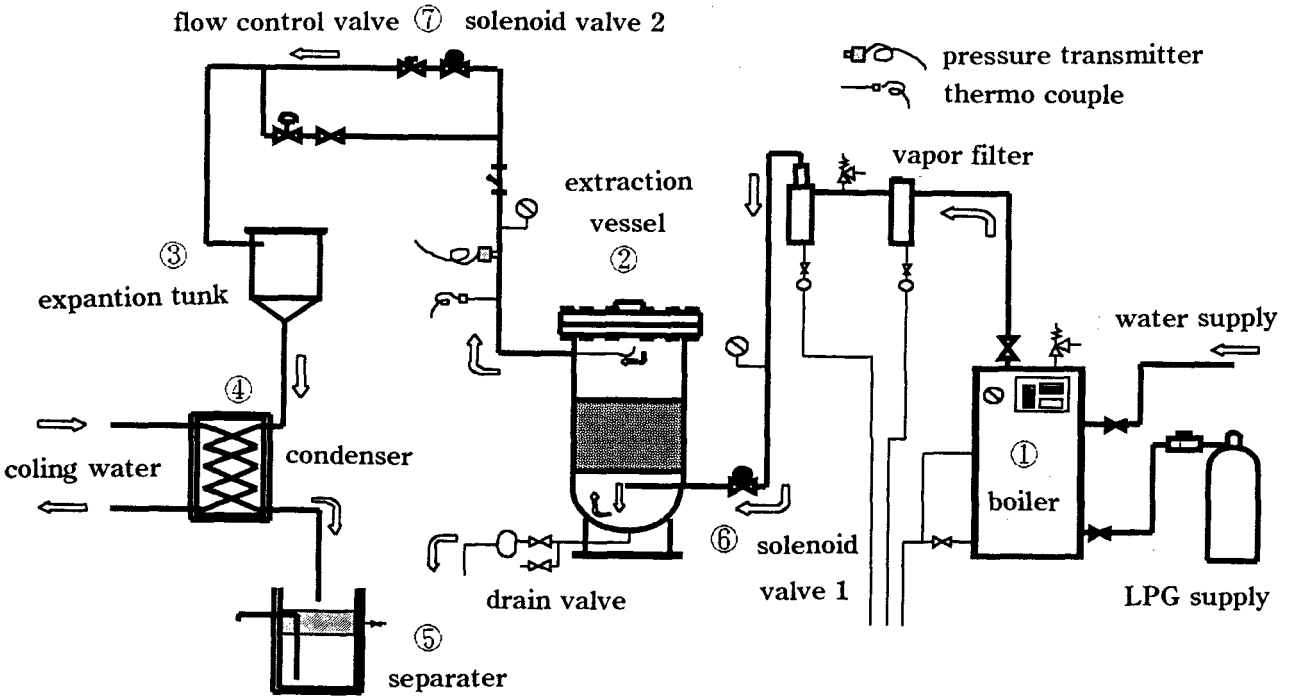

Figure 1. Flow diagram of SPE system.

extraction with 30L and 10L (2), two SUS made expansion tanks with 200L and a cyclone (3),a condenser made of SUS plate heat exchanger (4) and a separator(5). Pressurized steam by the boiler(1) was fed to the extraction vessel(2) and then expanded to the expansion tank(3). The extracted oil and vapor mixtures were condensed by means of a water cooled plate heat exchanger and the oil was thereafter separated at the separator(5) and then the amount of extracted oil was measured.

2.2 Experimental Procedure

Experiments were carried out to study the effect of operating pressure 1 to 3Kgf／cm2. Test samples were sawdust of HIBA including crashed pellet by chipping.

The SPE process is proceeded in the following.

(1) The steam was fed to the extraction vessel through an electric pressure regulating valve (6) and then its extraction vessel was pressurized to a given value ,while an electric outlet pressure regulating valve (7) was closed.

(2) After reaching the prescribed value, it was depressurized to atmosphere through the valve(7),while the valve (6) was closed.

(3) The above procedures (1) and (2) were repeated.

(4) The extracted oil and vapor mixtures were introduced to the condenser through the expansion tank. The condensed oil was separated from mixtures by the water−oil separator due to a different specific gravity. The amount of extracted oil was measured every 10 minutes.

(5) One extraction process time was chosen to be 3 hours from the beginning of condensation.

3. RESULTS AND DISCUSSIONS

Test results are shown as Fig.2 and Fig.3 in order to demonstrate the change of operating pressure. Figure 2 shows a variation of an extraction rate in addition to its integral quantity vs time under the conditions of an operating pressure of 1 atmosphere,a sample mass of 11.8kg and a steam flow rate

of 13.9kg / h . While figure 3 shows that of 3 kg / cm2 by the SPE under a sample mass of 11.6 kg and a steam flow rate of 14.5 kg / h.

It was found that the extraction rate was larger in SPE method than in atmospheric extraction method ,moreover the integral quantity has a tendency to increase with increase of steam quantity. This tendency decreases with an increase of peak pressure. Figure 4 shows typical behaviors of operating pressure and temperature vs time in the pressure swing process.

Notice that the peak value of extraction rate came earlier in the SPE than in the atmospheric case.Thus SPE enables us to shorten the extraction process time.The reason is derived from a short time for vapor equilibrium of essential oil component in the cell by changing pressure.

As shown in Fig. 4 the temperature was changing periodically as well as the pressure so that an averaged temperature of the source material became lower in SPE than in a constant pressure extraction with a continuous feed of steam. For the extraction by continuous pressurized steam there was observed a smell of burning in the oil,while for the SPE there was not any smell of burning. Moreover the flavor of product oil was like that of atmospheric extraction. This is considered to be caused by small quantities of impurity generation as furfural and organic acids due to a decomposition of polysaccharide.

The SPE gave us a stable production of oil since there existed very small oil residues in the system by adding pressure pulsation, that is, the degradation of cooling effect was very small with decrease of oil residues on the heating surface. Furthermore the yield of oil was increased due to easy contact between oil in the cell and steam by a partial fracturing of wood texture. This behavior of the SPE is useful for an application of chip source materials as well as sawdust.

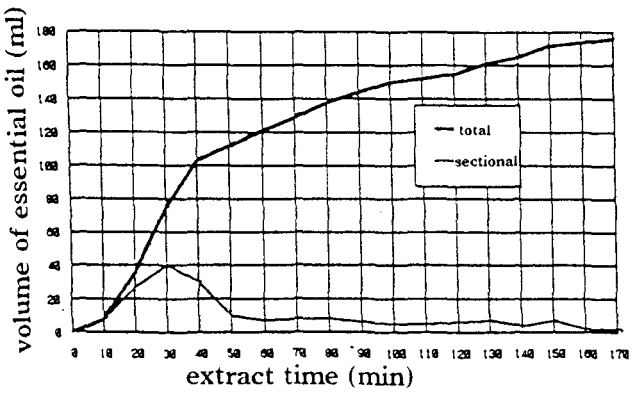

Figure 2. Variation of extraction rate & integral amount vs time (atmospheric extraction).

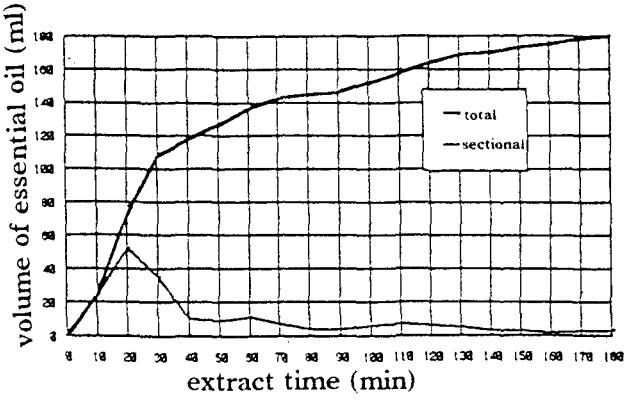

Figure 3. Variation of extraction rate & integral amount vs time (SPE).

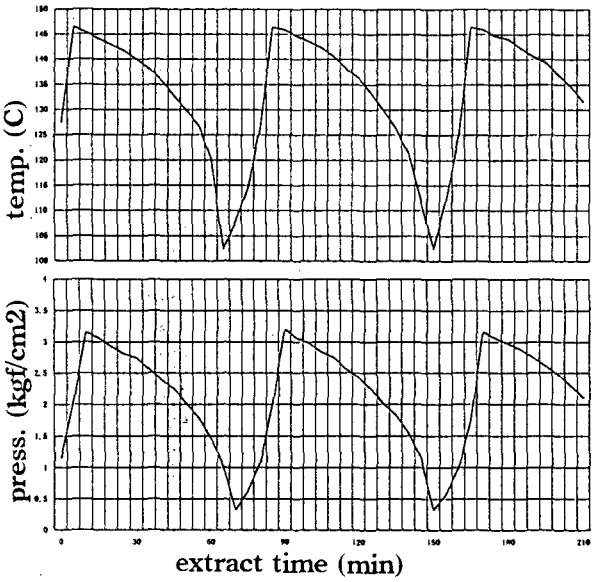

Figure 4. Variation of operating pressure & temperature vs time by SPE.

4. CONCLUSIONS

The following conclusions were obtained from the present work.

(1) Amount of total oil product was larger by the SPE than by the atmospheric steam extraction,in addition its initial extraction rate was also larger compared to the atmospheric case.

(2) There was not observed a smell of burning which was encountered in the case of usual pressurized extraction. The SPE is favorable for using an essential oil as a natural perfume.

(3) The yield of product oil increases with increase of peak pressure and steam,however it seems that there is an optimum values.

REFERENCE

1 T.Okabe and K.Saito Wood Preservataion 19(2),18–28(1993)