Determination of some important emissions of sunflower oil production industrial wastes incineration

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 Seeds of sunflower (Helianthus annuus L) yield oil (38-42%), which constitutes the largest vegetable oil produced in Turkey. In 20011, from 595,000 ha in Turkey, 950,000 t of sunflower seeds were produced. Seed hull is composed of: cellulose, 50-60; furfural, 9-15; water, 9-10; wax and waxy materials, 1-8; silica, 1-2; ash, 6.90; and oil, 1 %. The calorific value of hull (2500-2700 kcal/kg) is close to that of wood (3000-3500 kcal/kg). Utilization of sunflower hull as an energy source in facility incineration furnaces during the production of sunflower oil might be a noteworthy method. However, this situation leads to some problems in the legal procedures. Although the fuel types are classified in the article Appendix-7 of the Air Quality Protection Legislation (AQPL) of Turkey, the use of sunflower seed hull as an energy source is not classified. In this study, environmental effects of removal of the process wastes by incineration in a typical sunflower oil production plant (also the reduction of these effects) are analyzed. In addition, the possible negative environmental effects of the combustion gases and the energy that is obtained as a result of the incineration are compared. The stack gas emissions that might be produced because of the incineration of about 285,000 t/y process wastes produced in Turkey are discussed in accordance with AQPL of Turkey.

Keywords: Sunflower oil production, Incineration, Air Quality Protection Legislation, Hull, Bio-energy

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Introduction

Sunflower (Helianthus annuus L), a widely produced agricultural crop (Table 1), has a significant place in Turkey’s economy. The major product of sunflower is seed oil, besides seed meal and hull2,3. Turkish seed consists: oil, 38-42; meal, 28-33; and hull, 29-30% (fresh weight basis)4,5.

During the production of sunflower oil, meal and hull are obtained as main by-products. Meal is utilized as feed for animals. The hull is either used to obtain energy or it is sent to solid waste landfill sites. At most, 1 percent of the seed oil exists in the hull3. Besides, sunflower hull has a thermal value of 2500-2700 kcal/kg, which is close to that of wood (3000-3500 kcal/kg)6. Utilization of sunflower hull as an energy source in facility combustion boilers during the production of sunflower oil, where thermal processing is required, might be considered to be a noteworthy method. However, this results in problems in the legal procedures in Turkey7, since the emissions from the incineration are not defined yet. Assuming that 90 percent of the seed is used to produce oil8 and the seed is composed of oil (40%), hull (30%) and meal (30%); the production of oil and by-products remained constant during 1999-2001 in Turkey (Table 2). This study analyzes utilization of sunflower hulls for energy production.

Materials and Methods

Sunflower hull is used as fuel in the combustion boiler of a plant (capacity, 500 t/d), where sunflower oil is produced for experimental researches. During these test burns, the amounts of the combustion gases (CO, SO2, NOx) were measured using MRU gas analyzer equipment, total volatile organic carbons (VOC) by

<table>
<thead>
<tr>
<th>Year</th>
<th>Annual production thousand tons</th>
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<tr>
<td>1970</td>
<td>375</td>
<td>1997</td>
<td>900</td>
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<td>2000</td>
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<tr>
<td>1996</td>
<td>780</td>
<td>2001</td>
<td>950</td>
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Table 1—Sunflower production in Turkey
Photovac 2020 Photoionization Air Monitor equipment and total particulate matter (TPM) by MIE DataRAM equipment at the measurement points of the stacks of the plant’s boilers.

There were two combustion boilers with following technical specifications: fuel type, fuel oil No. 4; calorific value of fuel, 9650 kcal/kg; fuel consumption, 6 t/d; boiler production year, 1975; stack no., 1; thermal power, $2.84 \times 10^3$ kW; and heating area, 275 m$^2$. Technical specifications of two stacks were as follows: Stack height, 20 m (limit, 19 m); height from roof, 6 m (limit, 3 m); roof type, inclined; and stack cross-sectional area, 0.63 m$^2$. Under normal conditions, fuel oil No. 4 is used as a fuel according to the Air Quality Protection Legislation (AQPL) of Turkey. Within the extent of this study, sunflower hull and fuel oil No. 4 were burned in test burns and stack gas emissions were determined by taking measurements. These values were compared with AQPL and the limiting values determined in AQPL (Table 3).

### Results and Discussion

Under normal conditions, when fuel oil No. 4 is burned in the plant, the intervals of values of the gases were measured as: CO, 18-23; SO$_2$, 2031-2105; and NO$_x$, 240-293 mg/m$^3$; and stack gas temp, 180-190°C. When sunflower hulls were used as fuel, the following values were recorded at the boiler stacks: CO, 8117-9025; SO$_2$, 277-314; and NO$_x$, 189-192 mg/m$^3$, stack gas temp, 181-187°C. In addition, TPM and VOC measurements were also carried out. Stack gas emissions of fuel oil No. 4 are given in Table 5. Average of at least three measurements were taken at each step.

The values of CO are found to be as high as 8117-9025 mg/m$^3$ (Table 4). These values exceed the limiting values of all of the fuel types in the legislation though it is observed that the values of SO$_2$, which is a general problem in plants where solid or liquid fuels are used, are quite low (18-21 mg/m$^3$). In accordance with AQPL,
the limiting value for plants, where solid fuel is used, is 400 mg/m$^3$, and the same for liquid fuel is 1700 mg/m$^3$. In addition, NO$_x$ are measured at 189-192 mg/m$^3$ where the limiting value is 800 mg/m$^3$ in the legislation. Low temperatures are considered to be effective on the low NO$_x$ concentrations measured in the stack gases during the test burns. The amount of TPM is 230-320 mg/m$^3$ (Table 4), while the limiting value for solid fuels is 150-450 mg/m$^3$ and the same for liquid fuels is 70-150 mg/m$^3$ according to the legislation. Total VOC values were noticed to be as low as 18.6-34.5 ppm.

Conclusions

Sunflower hulls, as fuel, are not defined in the AQPL. This result has no possibility to compare with any criterion. Because the rate of mass flow of the dust emissions, formed after combustion, is high, wet system stack filters should be applied in these plants. Furthermore, CO quantities should be decreased by regulating the air-fuel ratios of the burning system. The observation of SO$_2$ at low values can be evaluated as a positive result. The stacks of the boilers emit high amounts of dust to the atmosphere after burning of the hulls. Moreover, CO emissions were high since the combustion was not complete. In order to provide necessary combustion conditions, combustion boilers developed specially for sunflower hulls should be used and particulate matters’ emission values should be decreased by using appropriate filtering systems (e.g. electrostatic filter) from the values obtained in the test burns. Successful applications of appropriate sunflower hull burning systems are carried out in USA, some European countries and Singapore, and similar systems might be established in Turkey, and thus environmentally problematic sunflower hull can be incinerated to obtain bio-energy. However, it might be appropriate to make necessary arrangements and regulations in the legislations for the appropriate incineration conditions for this new fuel. The existence of the emission limits for these kinds of fuels in the AQPL will enable these emission limits to be inspected in the plants where this kind of burning processes are carried out. It is necessary to investigate such burning conditions and burning systems that will not be harmful to the environment in case of sunflower hull incineration. Continuation of similar researches will be worthwhile from the evaluation of hulls by incineration point of view.

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References

3 Nas S, Gokalp H Y & Unsal M, Vegetable Oil Technology (in Turkish) (University of Ankara, Faculty of Agricultural Textbook, Press No.64, Erzurum, Turkey) 1992.
4 Ozeris S, Fundamental Organic Chemistry (in Turkish) (Istanbul University, Faculty of Engineering, Department of Chemistry, Istanbul, Turkey) 1987.
7 Air Quality Protection Regulation, Turkish Regulation, Turkish Official Gazette (in Turkish) (November 2, 1986, Issue No. 19269), Ankara, Turkey.

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