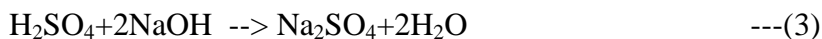
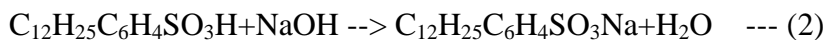
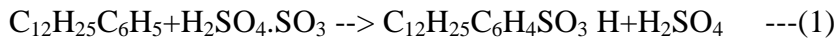


## 4.MATERIAL BALANCE

Assumptions:

- 1) No sulfonic acid passes into the spent acid.
- 2) Sulphuric acid left in the sulfonic acid has the same strength as the spent acid.
- 3) Sodium sulfonate product is 85% active.
- 4) Ratio of oleum to alkylate is 1.1
- 5) Possible side reactions are neglected.

Reactions:



Product: 2,50,000 kg/day.

$$\begin{aligned} \text{With 85\% active} &= 2,12,500 \text{ kg/day} \\ &= 8854.2 \text{ kg/hr.} \end{aligned}$$

Amount of alkyl aryl sulfonic acid produced

$$\begin{aligned} &= 8854.2(326/348) \\ &= 8294.4 \text{ kg/hr.} \end{aligned}$$

**Sulfonator:**

Consider reaction (1)

Basis: 8294.4 kg/hr of sulfonic acid.

$$\begin{aligned}\text{Amount of alkyl benzene} &= 8294.4(246/326) \\ &= 6258.97 \text{ kg/hr} = 25.44 \text{ kmole/hr}\end{aligned}$$

Conversion is 98%

$$\begin{aligned}\text{Alkyl benzene} &= 25.96 \text{ kmoles / hr} \\ &= 6386.7 \text{ kg/hr.}\end{aligned}$$

$$\begin{aligned}\text{Oleum taken(in practice)} &= 1.1 \times 6386.7 \\ &= 7025.38 \text{ kg/hr}\end{aligned}$$

$$\begin{aligned}\text{SO}_3 \text{ required} &= 8294.42 (80/326) \\ &= 2035.4 \text{ kg/hr}\end{aligned}$$

[1 kg of 20% oleum contains 0.2 kg of SO<sub>3</sub> & 0.8 kg of H<sub>2</sub>SO<sub>4</sub>.

i.e.  $0.8(80/98)+0.2=0.853$  kg of SO<sub>3</sub>

$0.8 (18/98) = 0.147$  kg of H<sub>2</sub>O]

Water associated = 366.56 kg

Total theoretical oleum required = 2402 kg/hr.

Oleum taken contains 5992.6 kg of SO<sub>3</sub> and 1032.73 kg of H<sub>2</sub>O

Excess SO<sub>3</sub> = 3957.2 kg

$$\begin{aligned}\text{H}_2\text{SO}_4 \text{ formed} &= 3957.2 (98/80) \\ &= 4847.88 \text{ kg/hr}\end{aligned}$$

$$\begin{aligned}\text{Additional water} &= 1032.7 - (3957.2 \times 18/80) \\ &= 142.36 \text{ kg}\end{aligned}$$

Concentration of H<sub>2</sub>SO<sub>4</sub> = 97.15%

$$\begin{aligned}\text{Unreacted alkyl benzene} &= 6386.7 \times 0.02 \\ &= 127.7 \text{ kg/hr}\end{aligned}$$

**Separator :**

Total reaction mixture = 13412.1 kg/hr

10% of water = 1341.2 kg/hr

Total mixture = 14753.3 kg/hr

Concentration of  $\text{H}_2\text{SO}_4$  = 76.6%

Sulfonic acid layer contains 5-6% of  $\text{H}_2\text{SO}_4$ .

Let us take 5.5%

i.e.  $5.5/0.766 = 7.2\%$  of 76.6% sulfuric acid

$\text{H}_2\text{SO}_4$  in sulfonic acid layer =  $8294.4 \times 7.2/92.8$   
= 643.5 kg/hr

Total acid mixture = 8937.95 kg/hr

Amount of spent acid = 5815.35 kg/hr

$\text{H}_2\text{SO}_4$ (76.6%) present in the sulfonic acid layer contains 492.9 kg  $\text{H}_2\text{SO}_4$  & 150.6 kg  $\text{H}_2\text{O}$

### **Neutraliser:**

Consider equation(3)

20% NaOH is added into the neutraliser.

$\text{Na}_2\text{SO}_4$  formed =  $492.94 \times 142/98$   
= 714.3 kg/hr.

NaOH required =  $492.44 \times 80/98$   
= 402.4 kg

$\text{H}_2\text{O}$  associated = 1609.6 kg

Total 20% NaOH = 2012 kg/hr

$\text{H}_2\text{O}$  produced=181.1kg/hr

Consider equation(2)

NaOH required = 1017.7 kg

$\text{H}_2\text{O}$  associated = 4070.88 kg

Total 20% NaOH = 5088.6 kg/hr

H<sub>2</sub>O produced = 457.97 kg/hr

Total amount of water = 4528.8 kg

Total amount of water present in the neutralizer = 6470.12 kg/hr

Product from the neutralizer contains 42% water .

**Dryer:**

Product from the dryer contains 8854.2 kg of alkyl aryl sulfonate, 714.258 kg of sodium sulfate and rest water (8%).

Total amount of water evaporated = 5621.9 kg/hr.