Generic Mineral Transformer Oil

Product Selection and Description

Mineral oil-based transformer oil can be made from either naphtha or paraffin. Since the naphthenic-based mineral oil carries a larger market share, it is used as the mineral oil base for the product in BEES.[1]

Flow Diagram

The figure below shows the elements of mineral oil-based transformer oil production.

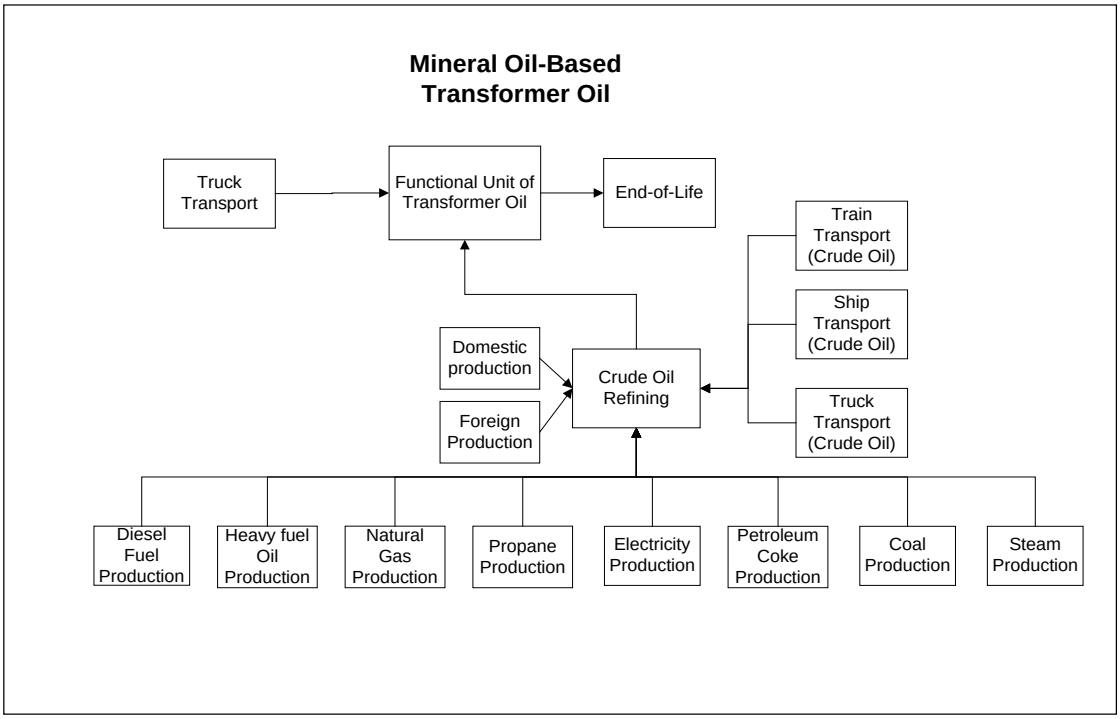

Figure 1: Mineral Oil-Based Transformer Oil System Boundaries

Raw Materials

Mineral-oil based transformer oil is composed of the materials listed in the Table below. The density of the oil is assumed to be 0.864 kg/L .[2]

Table 1: Mineral-Oil Based Transformer Oil Constituents

Constituent	*Mass (kg/kg oil)*
Naphtha	98 %
Pour-point depressives and other additives	2 %

The production of naphtha requires extraction of crude oil and crude oil refining; since naphtha is just one of many oil refinery products, only a portion of the inputs and outputs to these processes is allocated to naphtha production. Data for these inputs and outputs is based on the SimaPro and U.S. LCI Databases, as detailed below.

Crude Oil Extraction. This production component includes process flows associated with the extraction of crude oil from the ground. U.S. LCI Database data used to represent extraction from onshore and offshore

[1] 2001 telephone conversation with United Power Services, an independent transformer oil testing laboratory.
[2].From http://www.shell-lubricants.com/Electrical/diala_hfx.html and http://www.camd.lsu.edu/msds/t/transformer_oil.htm.

wells range from the late 1990s to early 2000s.

Crude Oil Refining into Naphtha. Crude oil refining involves raw material and energy use as well as emissions. Crude oil refining is based on an average U.S. refinery. It is assumed that the material required by the refinery includes crude oil and other petroleum-based feedstocks, purchased energy inputs, and process catalysts.

Crude oil refineries draw much of their energy requirements from the crude oil stream in the form of still gas and catalyst coke as shown in the Table below. Additional energy requirements and process needs are fulfilled by the other inputs listed in the Table.[3]

Table 2: U.S. Average Refinery Energy Use

Energy Carrier	***Annual Quantity (MJ)***
Still Gas	1.52E+12
Catalyst Coke	5.14E+11
Natural Gas	7.66E+11
Coal	3.27E+09
Steam	3.8E+10
Electricity	1.43E+11
Propane (C3H8, kg)	6.21E+10
Diesel Oil (kg)	3.16E+09
Heavy Fuel Oil	6.13E+10
Coke	1.77E+10
Other	8.8E+09

The emissions and energy requirements associated with the production of these fuels are accounted for. Emissions are based on U.S. Environmental Protection Agency AP-42 emission factors.

Allocation. Crude oil refineries produce a number of different petroleum products from crude oil. The method for allocating total refinery energy use and total refinery emissions to the production of naphtha is complicated by the fact that the refinery product mix is variable, both among refineries and even with time for a given integrated refinery. The following method is used to allocate refinery flows to naphtha production:

1. Calculate the percentage of total refinery energy use by refinery process.
2. Calculate naphtha's share of each process's energy consumption.
3. For each refinery process, multiply the corresponding results from steps 1 and 2 to get the percentage of total refinery energy use allocated to naphtha refining

Manufacturing

Energy Requirements

After producing naphtha, pour-point depressives and other additives such as antioxidants are added to give the transformer oil the properties it needs. The specifics for these additives can not be reported because they are confidential, but their production data come from the SimaPro

database. The assumed energy requirement for producing the transformer oil is given in the Table below.[4]

[3] Energy Information Administration, *Petroleum Supply Annual 1994*, Report No. DOE/EIA-0340(94)/1, May 1995.

[4] This data is based on confidential energy requirement data gathered for biobased transformer oil production (summer 2005). It is used in the absence of more representative manufacturing energy information for this product.

Table 3: Energy Requirement for Mineral-Oil Based Transformer Oil Production

Requirement	*Quantity (per kg oil)*
Production Energy	1.6 MJ (0.44 kWh)

Transportation

Trucking is the mode of transport representing transportation from the transformer oil production plant to the transformer to be filled at the point of use. The transportation distance is modeled as a variable of the BEES system. Only trucking is modeled, and not pipeline transportation, since transformer oil is a specialty petroleum product with a tiny market as compared to other petroleum products. As a result, pipeline transportation burdens allocated to transformer oil are assumed to be insignificant.

Use

The amount of oil used in a transformer depends on the size of the transformer. A relatively small-sized (1 000 kV·A) transformer is assumed, which requires about 1.89 m^3 (500 gal) of fluid to cool. It is assumed that the use phase of the transformer oil lasts the lifetime of the transformer, approximately 30 years. Included in the modeling is the electricity required to recondition the oil when dissolved gas analysis tests indicate the need. Reconditioning is assumed to occur every five years.[5]

End of Life

With periodic reconditioning of transformer oil during the 30-year life of the transformer, the oil can be further reconditioned and reused in another transformer at end of life. This is assumed to be the case; none of the product is landfilled.

References

Life Cycle Data

National Renewable Energy Laboratory (NREL): *U.S. Life-Cycle Inventory Database*. 2005. Golden, CO. Found at: http://www.nrel.gov/lci/database.

PRé Consultants: *SimaPro 6.0 LCA Software*. 2005. The Netherlands.

[5] Information on dissolved gas analysis testing can be found in the U.S. Bureau of Reclamation (USBR) website's Facilities Instructions Standards and Techniques (FIST) document, http://www.usbr.gov/power/data/fist_pub.html . Energy information on reconditioning was provided during telephone conversations with S.D. Myers, a transformer and transformer fluid contractor, November 2001.