[CLAIMS]

1. An operating condition estimation system comprising:

a learning apparatus that learns a condition estimator for estimating an operating condition of a fluid catalytic cracking apparatus, from information adapted to be acquired, while the fluid catalytic cracking apparatus is being operated, from a sensor, an appliance, an apparatus, a facility, or a control apparatus for setting control variables for controlling an operating condition of the sensor, the appliance, the apparatus, or the facility, provided in an oil refinery in which the fluid catalytic cracking apparatus is provided, a value of the information differing depending on whether the fluid catalytic cracking apparatus is in a normal operating condition or in an afterburn condition, the fluid catalytic cracking apparatus including a reaction apparatus in which a catalyst is used and a regeneration apparatus for regenerating the catalyst; and

an estimation apparatus that estimates the operating condition of the fluid catalytic cracking apparatus by using the condition estimator learned by the learning apparatus based on the information acquired while the fluid catalytic cracking apparatus is being operated, wherein

the learning apparatus includes:

a learning data acquisition unit that acquires, as learning data, the information acquired when the fluid

catalytic cracking apparatus was operated in the past; and

a learning unit that learns the condition estimator through machine learning, using the learning data acquired by the learning data acquisition unit, and

the estimation apparatus includes:

an operation data acquisition unit that acquires the information acquired while the fluid catalytic cracking apparatus is being operated;

an operating condition estimation unit that estimates the operating condition of the fluid catalytic cracking apparatus by inputting the information acquired by the operation data acquisition unit to the condition estimator; and

an estimation result output unit that outputs information indicating the operating condition of the fluid catalytic cracking apparatus estimated by the operating condition estimation unit, wherein

the operating condition includes at least two of a condition in which afterburn does not occur in the regeneration apparatus, a condition in which afterburn occurs in the regeneration apparatus, and a condition in which the regeneration apparatus is making a transition from a condition in which afterburn does not occur to a condition in which afterburn occurs.

2. An operating condition estimation system comprising:

a learning apparatus that learns a condition estimator for estimating an operating condition of a fluid catalytic cracking apparatus from information adapted to be acquired, while the fluid catalytic cracking apparatus is being operated, from a sensor, an appliance, an apparatus, a facility, or a control apparatus for setting control variables for controlling an operating condition of the sensor, the appliance, the apparatus, or the facility, provided in an oil refinery in which the fluid catalytic cracking apparatus is provided, a value of the information differing depending on whether the fluid catalytic cracking apparatus is in a normal operating condition or in an afterburn condition, the fluid catalytic cracking apparatus including a reaction apparatus in which a catalyst is used and a regeneration apparatus for regenerating the catalyst; and

an estimation apparatus that estimates the operating condition of the fluid catalytic cracking apparatus by using the condition estimator learned by the learning apparatus based on the information acquired while the fluid catalytic cracking apparatus is being operated, wherein

the learning apparatus includes:

a learning data acquisition unit that acquires, as learning data, the information acquired when the fluid catalytic cracking apparatus was operated in the past; and

a learning unit that learns the condition estimator

through machine learning, using the learning data acquired by the learning data acquisition unit, and

the estimation apparatus includes:

an operation data acquisition unit that acquires the information acquired while the fluid catalytic cracking apparatus is being operated;

an operating condition estimation unit that estimates the operating condition of the fluid catalytic cracking apparatus by inputting the information acquired by the operation data acquisition unit to the condition estimator; and

an estimation result output unit that outputs information indicating the operating condition of the fluid catalytic cracking apparatus estimated by the operating condition estimation unit, wherein

the condition estimator calculates a feature amount having a smaller number of dimensions than the information acquired by the learning data acquisition unit.

3. The operating condition estimation system according to claim 2, wherein

the learning unit learns the condition estimator so that the feature amount calculated by the condition estimator from the learning data is grouped into different clusters depending on the operating condition of the fluid catalytic cracking apparatus occurring when the learning data is

acquired.

4. The operating condition estimation system according to claim 2 or 3, wherein

the feature amount is two-dimensional or three-dimensional, and

the estimation result output unit outputs a chart showing the feature amount plotted in a two-dimensional coordinate space or a three-dimensional coordinate space.

5. The operating condition estimation system according to claim 4, wherein

the estimation result output unit retains a correlation between coordinates of the feature amount in a two-dimensional coordinate space or a three-dimensional coordinate space and the operating condition of the fluid catalytic cracking apparatus and further outputs the operating condition of the fluid catalytic cracking apparatus corresponding to the feature amount calculated by the condition estimator.

6. The operating condition estimation system according to claim 1, wherein

when the information acquired when the fluid catalytic cracking apparatus was operated at a predetermined point of time in the past is input to the condition estimator, the

learning unit learns the condition estimator so that a predicted value of a different type of information acquired after an elapse of a predetermined period of time since the predetermined point of time is output from the condition estimator.

7. An operating condition estimation system comprising:

a learning apparatus that learns a condition estimator for estimating an operating condition of a fluid catalytic cracking apparatus from information adapted to be acquired, while the fluid catalytic cracking apparatus is being operated, from a sensor, an appliance, an apparatus, a facility, or a control apparatus for setting control variables for controlling an operating condition of the sensor, the appliance, the apparatus, or the facility, provided in an oil refinery in which the fluid catalytic cracking apparatus is provided, a value of the information differing depending on whether the fluid catalytic cracking apparatus is in a normal operating condition or in an afterburn condition, the fluid catalytic cracking apparatus including a reaction apparatus in which a catalyst is used and a regeneration apparatus for regenerating the catalyst; and

an estimation apparatus that estimates the operating condition of the fluid catalytic cracking apparatus by using the condition estimator learned by the learning apparatus

based on the information acquired while the fluid catalytic cracking apparatus is being operated, wherein

the learning apparatus includes:

a learning data acquisition unit that acquires, as learning data, the information acquired when the fluid catalytic cracking apparatus was operated in the past; and

a learning unit that learns the condition estimator through machine learning, using the learning data acquired by the learning data acquisition unit, and

the estimation apparatus includes:

an operation data acquisition unit that acquires the information acquired while the fluid catalytic cracking apparatus is being operated;

an operating condition estimation unit that estimates the operating condition of the fluid catalytic cracking apparatus by inputting the information acquired by the operation data acquisition unit to the condition estimator; and

an estimation result output unit that outputs information indicating the operating condition of the fluid catalytic cracking apparatus estimated by the operating condition estimation unit, wherein

when the information acquired when the fluid catalytic cracking apparatus was operated at a predetermined point of time in the past is input to the condition estimator, the learning unit learns the condition estimator so that a

predicted value of a different type of information acquired after an elapse of a predetermined period of time since the predetermined point of time is output from the condition estimator, and

the learning unit adjusts a weight of each of a plurality of types of the information acquired by the learning data acquisition unit from which information the condition estimator calculates the predicted value, based on a result of fault tree analysis in which an occurrence of afterburn in the regeneration apparatus is defined as an event above.

8. The operating condition estimation system according to claim 7, wherein

the learning unit adjusts, based on a difference between a) the predicted value calculated by the condition estimator learned by using, as learning data, particular information of the plurality of types of the information acquired by the learning data acquisition unit and b) the predicted value calculated by the condition estimator learned without using the particular information as learning data, the weight of the particular information.

9. The operating condition estimation system according to claim 8, wherein

the estimation result output unit outputs the predicted

value calculated by the condition estimator learned by using the particular information as learning data and the predicted value calculated by the condition estimator learned without using the particular information as learning data.

10. An operating condition estimation system comprising:

a learning apparatus that learns a condition estimator for estimating an operating condition of a fluid catalytic cracking apparatus, from information adapted to be acquired, while the fluid catalytic cracking apparatus is being operated, from a sensor, an appliance, an apparatus, a facility, or a control apparatus for setting control variables for controlling an operating condition of the sensor, the appliance, the apparatus, or the facility, provided in an oil refinery in which the fluid catalytic cracking apparatus is provided, a value of the information differing depending on whether the fluid catalytic cracking apparatus is in a normal operating condition or in an afterburn condition, the fluid catalytic cracking apparatus including a reaction apparatus in which a catalyst is used and a regeneration apparatus for regenerating the catalyst; and

an estimation apparatus that estimates the operating condition of the fluid catalytic cracking apparatus by using the condition estimator learned by the learning apparatus

based on the information acquired while the fluid catalytic cracking apparatus is being operated, wherein

the learning apparatus includes:

a learning data acquisition unit that acquires, as learning data, the information acquired when the fluid catalytic cracking apparatus was operated in the past; and

a learning unit that learns the condition estimator through machine learning, using the learning data acquired by the learning data acquisition unit, and

the estimation apparatus includes:

an operation data acquisition unit that acquires the information acquired while the fluid catalytic cracking apparatus is being operated;

an operating condition estimation unit that estimates the operating condition of the fluid catalytic cracking apparatus by inputting the information acquired by the operation data acquisition unit to the condition estimator; and

an estimation result output unit that outputs information indicating the operating condition of the fluid catalytic cracking apparatus estimated by the operating condition estimation unit, wherein

the learning apparatus further includes a learning data generation unit that generates learning data by adjusting a plurality of types of the information acquired by the learning data acquisition unit according to an offset time

that depends on the type of the information, and

the estimation apparatus further includes an input data generation unit that generates input data input to the condition estimator by adjusting a plurality of types of the information acquired by the operation data acquisition unit according to the offset time that depends on the type of the information.

11. The operating condition according to claim 10, wherein

the plurality of types of the information include information indicating a temperature in the regeneration apparatus at a predetermined point of time and information indicating an operating condition of the reaction apparatus or the regeneration apparatus at a point of time before the predetermined point of time.

12. The operating condition estimation system according to any one of claims 1 through 11, wherein

the reaction apparatus processes a fluid having a boiling point equal to or higher than 170°C.

13. A learning apparatus comprising:

a learning data acquisition unit that acquires, as learning data, information acquired, when a fluid catalytic cracking apparatus was operated in the past, from a sensor,

an appliance, an apparatus, a facility, or a control apparatus for setting control variables for controlling an operating condition of the sensor, the appliance, the apparatus, or the facility, provided in an oil refinery in which the fluid catalytic cracking apparatus is provided, a value of the information differing depending on whether the fluid catalytic cracking apparatus is in a normal operating condition or in an afterburn condition, the fluid catalytic cracking apparatus including a reaction apparatus in which a catalyst is used and a regeneration apparatus for regenerating the catalyst; and

a learning unit that learns, through machine learning, a condition estimator for estimating an operating condition of the fluid catalytic cracking apparatus from the information, by using the learning data acquired by the learning data acquisition unit, wherein

the operating condition includes at least two of a condition in which afterburn does not occur in the regeneration apparatus, a condition in which afterburn occurs in the regeneration apparatus, and a condition in which the regeneration apparatus is making a transition from a condition in which afterburn does not occur to a condition in which afterburn occurs.

14. An estimation apparatus comprising:

an operation data acquisition unit that acquires, while

a fluid catalytic cracking apparatus is being operated, information acquired from a sensor, an appliance, an apparatus, a facility, or a control apparatus for setting control variables for controlling an operating condition of the sensor, the appliance, the apparatus, or the facility, provided in an oil refinery in which the fluid catalytic cracking apparatus is provided, a value of the information differing depending on whether the fluid catalytic cracking apparatus is in a normal operating condition or in an afterburn condition, the fluid catalytic cracking apparatus including a reaction apparatus in which a catalyst is used and a regeneration apparatus for regenerating the catalyst;

an operating condition estimation unit that estimates an operating condition of the fluid catalytic cracking apparatus by inputting the information acquired by the operation data acquisition unit to a condition estimator for estimating an operating condition of the fluid catalytic cracking apparatus, the condition estimator being learned through machine learning by a learning apparatus that learns the condition estimator by using, as learning data, the information acquired when the fluid catalytic cracking apparatus was operated in the past; and

an estimation result output unit that outputs operating condition information indicating the operating condition of the fluid catalytic cracking apparatus estimated by the operating condition estimation unit, wherein

the operating condition includes at least two of a condition in which afterburn does not occur in the regeneration apparatus, a condition in which afterburn occurs in the regeneration apparatus, and a condition in which the regeneration apparatus is making a transition from a condition in which afterburn does not occur to a condition in which afterburn occurs.

15. A computer-implemented method of generating a condition estimator, comprising:

acquiring, as learning data, information acquired, when a fluid catalytic cracking apparatus was operated in the past, from a sensor, an appliance, an apparatus, a facility, or a control apparatus for setting control variables for controlling an operating condition of the sensor, the appliance, the apparatus, or the facility, provided in an oil refinery in which the fluid catalytic cracking apparatus is provided, a value of the information differing depending on whether the fluid catalytic cracking apparatus is in a normal operating condition or in an afterburn condition, the fluid catalytic cracking apparatus including a reaction apparatus in which a catalyst is used and a regeneration apparatus for regenerating the catalyst; and

using the learning data acquired to learn, through machine learning, a condition estimator for estimating an operating condition of the fluid catalytic cracking apparatus

from information, wherein

the operating condition includes at least two of a condition in which afterburn does not occur in the regeneration apparatus, a condition in which afterburn occurs in the regeneration apparatus, and a condition in which the regeneration apparatus is making a transition from a condition in which afterburn does not occur to a condition in which afterburn occurs.

16. A computer-implemented estimation method comprising:

acquiring information acquired, while a fluid catalytic cracking apparatus is being operated, from a sensor, an appliance, an apparatus, a facility, or a control apparatus for setting control variables for controlling an operating condition of the sensor, the appliance, the apparatus, or the facility, provided in an oil refinery in which the fluid catalytic cracking apparatus is provided, a value of the information differing depending on whether the fluid catalytic cracking apparatus is in a normal operating condition or in an afterburn condition, the fluid catalytic cracking apparatus including a reaction apparatus in which a catalyst is used and a regeneration apparatus for regenerating the catalyst;

estimating an operating condition of the fluid catalytic cracking apparatus by inputting the information

acquired to a condition estimator for estimating an operating condition of the fluid catalytic cracking apparatus, the condition estimator being learned through machine learning by a learning apparatus that learns the condition estimator by using, as learning data, the information acquired when the fluid catalytic cracking apparatus was operated in the past; and

outputting operating condition information indicating the operating condition of the fluid catalytic cracking apparatus estimated, wherein

the operating condition includes at least two of a condition in which afterburn does not occur in the regeneration apparatus, a condition in which afterburn occurs in the regeneration apparatus, and a condition in which the regeneration apparatus is making a transition from a condition in which afterburn does not occur to a condition in which afterburn occurs.