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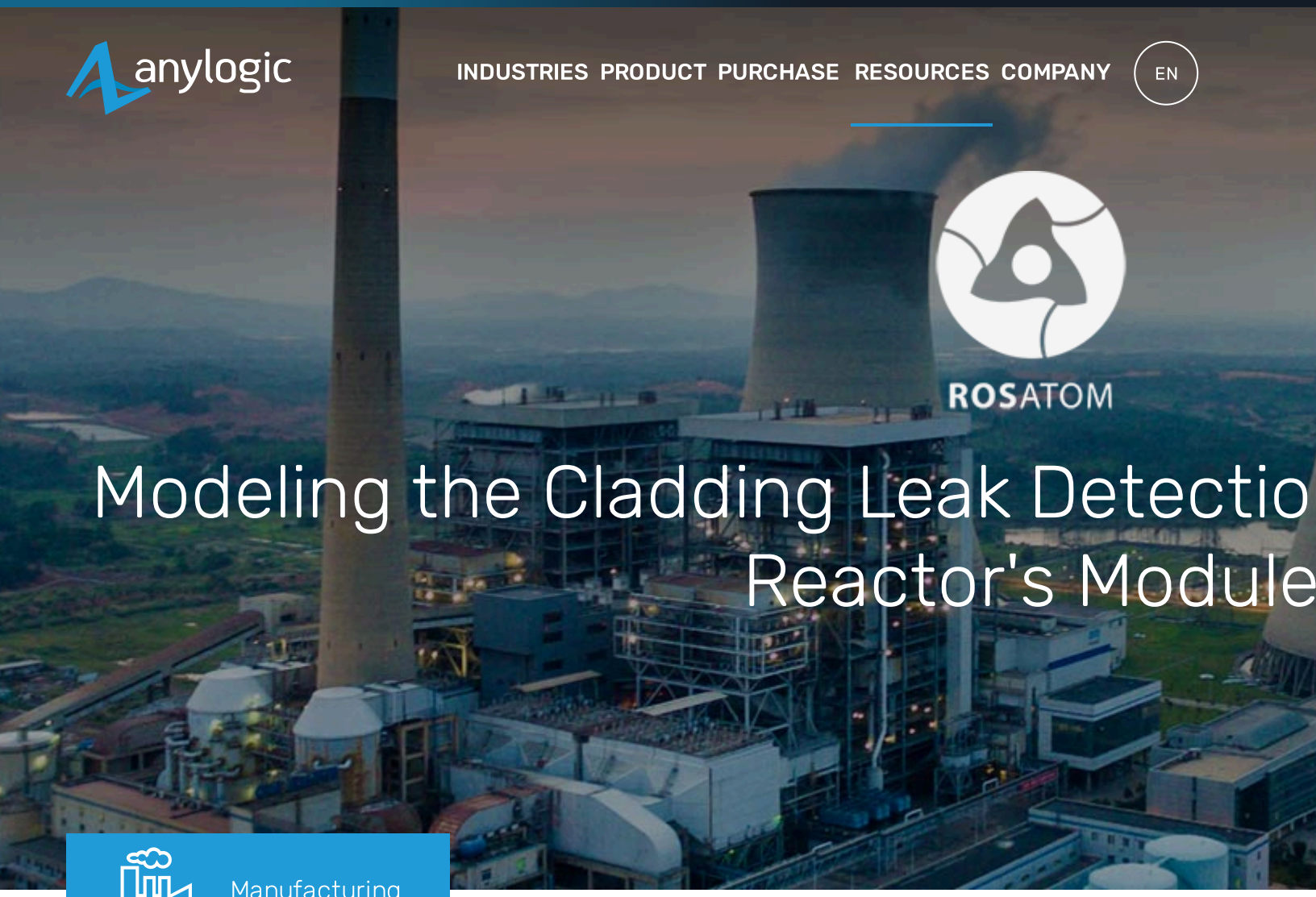

Modeling the Cladding Leak Detectio Reactor's Module

Manufacturing

Customer

Rosatom State Atomic Energy Corporation (Rosatom) is a state holding which incorporates more than 360 enterprises in the nuclear field. It includes all nondefense nuclear ventures, enterprises from the nuclear weapon sector, research organizations, and nuclear icebreaker fleets. Rosatom is a leading organization in the nuclear industry. It holds second

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When designing the fuel cladding leak detection shop, developers needed to collect the data and system parameters in cases of ruptured fuel elements production.

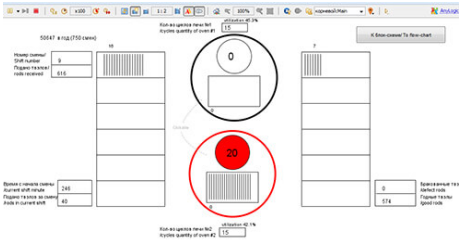
The cladding leak detection shop is part of an automated line of fuel assembly production. Leak control is based on heating the fuel element groups. While warming up, defective units eject the control gas, which is detected by a leak locator. The defected group is divided into two parts. Each part is screened in the same way until the leaking fuel element is found.

System engineers needed to define the dependence between annual output (production), input storage volume, and fuel element group size, to charge into furnace or different spoilage rate. In addition, they needed to define the amount of dead fuel elements assemblies due to system downtime when input storage is full.

Solution

Since leakage rate has a stochastic nature, developers built a simulation model of a cladding leak detection shop and tested different scenarios and system operation algorithms, running multiple experiments on the model.

The model, built in AnyLogic, simulates two algorithms of leak detection shop operation. The algorithms are based on different approaches for



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furnace #2. Both groups are heated and examined for leaking fuel elements. The qualified group is charged to the output storage. The defective group is again divided into two groups and examined for the leaking fuel element, and so on.

If both groups appear to be defective, half of each group is charged to the output storage and the examination of the rest of the halves begins. The fuel elements groups in the output storage are inspected after examination of the first halves is completed. The input storage picks up incoming assemblies with scheduled frequency. Thus, the ruptured group is "uncoiled" by two furnaces. A new group of fuel elements is not charged until the ruptured element is found. In case leakage is not detected, the furnaces operate in course, with the second furnace waiting for the first one to complete the examination of the fuel elements group.

Second algorithm: the furnaces operate independently. The ruptured group is "uncoiled" by a furnace in isolation from another until the leaking element is found. A new group of fuel elements is not charged into the furnace until the previous group is completely examined. This approach allows two furnaces to operate simultaneously.

Model user can vary the following parameters of algorithms:

- Leakage frequency
- Size of fuel elements group to charge into the furnace for examination
- Input storage size

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- The size of the fuel elements group to charge into a furnace was defined to provide the maximum production rate for the given leakage frequency.
- Simulation brought out the possible loss reduction due to down time if the volume of input storage is increased.
- Leak detector production stats were received for various leak frequencies and different parameters. Each time, the model was run for 100 "simulation" years.
- Simulation spotted the dependence between maximum volume of input storage and the size of the fuel elements group to charge into the furnace. Numerical values were received to express this dependence for various leak frequency.

Conclusion

At the stage of designing the fuel cladding leak detection shop, experiments with the real system required lots of financial and time expenses. Analysis of data collected during simulation allowed the engineers to define the optimal design parameters to provide maximum production.

The customer is planning to use the simulation model for testing possible changes in the production line, like adding a new furnace. Users can vary parameters by editing data in the model interface. The simulation model will serve as a decision support tool for the equipment buyer for many years.

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