

Sustainable Transport Systems
Professor Bhola Ram Gurjar
Department of Civil Engineering
Indian Institute of Technology, Roorkee
Lecture 57

Material Flow Analysis Tool – STAN


Hello friends, so, we are discussing the different kinds of tools which are used for analysis purpose like openLCA we have seen. So, in that category today we will discuss about Material Flow Analysis Tool STAN. Which is quite popular and it will give you a kind of a skill if you go through it and this is freely available software which can help you to see how this material flow analysis is done and how can we use it in terms of like transportation sector or any kind of other activities.


Basically, this is versatile. But you can also use for transportation systems also, but it is as such it is not particularly for transportation system, but, so, we will give the introductory part about this material flow analysis which we have already discussed, but we will discuss briefly. And then we will see about this STAN this tool how it is downloaded and how it is installed.

(Refer Slide Time: 01:23)

Contents

- Material Flow Analysis (MFA) revision
- STAN
 - Introduction & history
 - How to download and install STAN
 - Basic functions
 - Addition of flow, process and other values
 - Applications of STAN-MFA in transportation
 - Conclusion



 2


Then what are the basic functions and how it is applied what kind of things are there which are to be known, so, that you can use it for whatever purpose you want. But we will focus on largely on transportation systems.

(Refer Slide Time: 01:36)

Revision

Definition of Material Flow Analysis (MFA)

- Material flow analysis (MFA) is a systematic assessment of the flows and stocks of materials within a system defined in space and time.
-Brunner and Rechberger, 2004



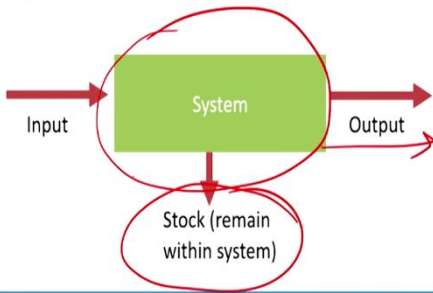
3

So, when we define the material flow analysis you already know that it is basically a systematic assessment of the flows and stocks of materials within a system within a boundary system defined in a space or in a time. So, temporal variations maybe there, spatial variations may be there but if you generate a boundary system within that what is the input? What is the output? Import, export and within the boundary system some changes are there in the stock that kind of things are there.

(Refer Slide Time: 02:08)

Revision

MFA concept equation

$$\text{Input} = \text{Output} + \text{Stock}$$


4

So, you have seen already these simple equations:

$$Input = Output + Stock$$

So, this is the boundary system and input is coming to this in the system. So, stock is the remain which within the system and output goes out of the system. So, basically output plus the stock is the input. So, that balance must be there.

(Refer Slide Time: 02:29)

Introduction (1/2)

- STAN (short for Substance Flow Analysis) is a freeware (free to use, but without open source) that helps to perform material flow analysis according to the Austrian standard.
- Developed by TU Wien, Institute for Water Quality, Resource and Waste Management
- Funded by: Altstoff Recycling Austria AG, Federal States of Austria
- STAN works on Windows operating systems only.

Software for Substance Flow Analysis
STAN
Technische Universität Wien 2

Developed by: D. Cencic, A. Kovacs. Supported by: J.D. Kelly, H. Flechberger
Published by: Institute for Water Quality, Resource and Waste Management
Funded by: APA - voestalpine - Lebensministerium - Federal States of Austria
© inka software

5

And this is the tool STAN which is software for substance flow analysis substance means material. So, material flow analysis is there and it is the free to use but of course it is not open source you cannot see it is all those coding, etc. But you can use it freely that is shown and it was developed by this Technical University Wien, Institute for Water Quality, Resources and Waste Management.


Because material flow analysis is very much used in water quality related or what resources related things. It was funded by Federal States of Austria and this works on Windows operating system. So very easy to use basically.

(Refer Slide Time: 03:13)

Introduction (2/2)

- For data import and export Microsoft Excel is used as an interface
- STAN is available in German and English.
- Builds a graphical model with predefined components (processes, flows, system boundary, text fields)
- Import known data (mass flows and stocks, volume flows and stocks, concentrations, transfer coefficients) for different layers (good, substance, energy) and periods to calculate unknown quantities.

It should be carefully noted that there are few other software (programming language etc. similar to the name.)



6



When we talk about like how to import data how to export. So, Microsoft Excel sheets are used that the excel programming you can do very simple kind of plus minus that is used and as in the interface in this particular style and it is available in German and English languages and the graphical models are very easy to use as per predefined components like processes, flows, system boundary, text fields.

So, you make some PPT slides, but in comparison to that it is very easy to make those kinds of things here also. And then you can import the known data which are input data mass flows, stocks, volume flows, etc., concentrations whatever quantity is there of the material and for different layers like goods or substances energy, and then you can calculate the unknown quantities that would be kind of output.

(Refer Slide Time: 04:12)

History of STAN

- The development of STAN began in 2004.
- Since then a lot of efforts have been made to bringing STAN to the next level.
 - Oct. 2006: Release of STAN 1.0
 - May 2009: Release of STAN 2.0
 - Sept. 2012: Release of STAN 2.5 and website www.stan2web.net
 - Oct. 2017: Release of STAN 2.6






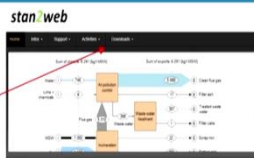
7

And the history if we go for the history of STAN, then it is improving year by year. Like in 2006. It was released STAN this first version. And in May 2009 STAN 2, version 2.0 version was released in September 2012, 2.5 version was there and the website is there stan2web dot net and October 2017 this STAN 2.6 the further, evolution was there. Otherwise, they started from 2004. So, last 12 to 13 years a lot of improvements have been there.

(Refer Slide Time: 04:52)

Downloading and installation

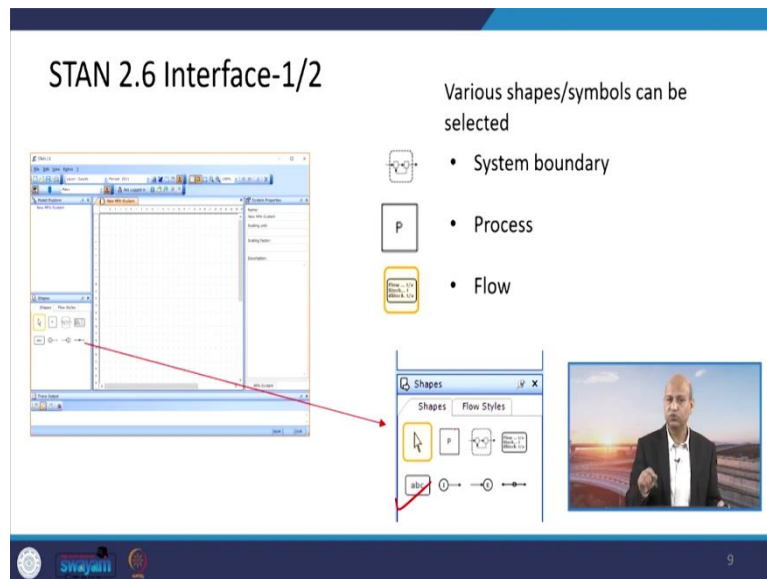
1. Open the website <https://www.stan2web.net/downloads>
2. Go to section download
3. Sign up
4. Click on STAN



8

So, when we talk about how do we really go for using this particular software or tool so first of all you need to visit this particular website where from you can download this tool in your, on your computer. So, visit this website www.stan2web.net and go to the downloads. So, you will see this kind of website and there you can see first of all you have to register yourself you have to sign up and then you can click this STAN here after signing up, then you can click the STAN and you can download it.

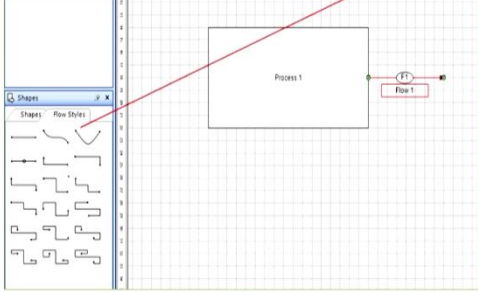
(Refer Slide Time: 05:30)




So, this is the interface which we will use, see after downloading when you will start using it. So, when it will be on the screen. So, this kind of screen will be visible and like system bound these kind of symbols are there; shapes and symbols are there. So, system boundary is there, then arrow figure or text is there and flow related diagrams are there, processes related p. So, all these are very easy to follow.

(Refer Slide Time: 05:58)

STAN 2.6 Interface-2/2



- Various types of flow styles can be used as per need of model.
- Creating model is very easy to use just as we use it in PPT presentations.

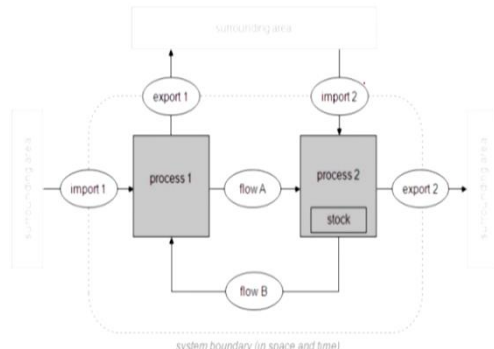


10

Then if you want to see like you want to show the flow from one point to another. So, different kinds of shapes of these flow styles are there like if only two points are joined straightway then straight line can be there with arrow. But if there are different kinds of features so, you have to go in different routes. So, depending on that, different kinds of shapes are there which can be used to show the flow style.


(Refer Slide Time: 06:28)

Sample model for MFA



The diagram illustrates a sample model for Material Flow Analysis (MFA). It shows a system boundary (in space and time) containing two processes: process 1 and process 2. Process 1 has an import 1 and an export 1. Process 2 has an import 2 and an export 2. There is a stock between process 1 and process 2. Flow A connects process 1 to process 2, and flow B connects process 2 back to process 1. The system is surrounded by sub-systems: manufacturing area, sub-system area, and business-enabling area.

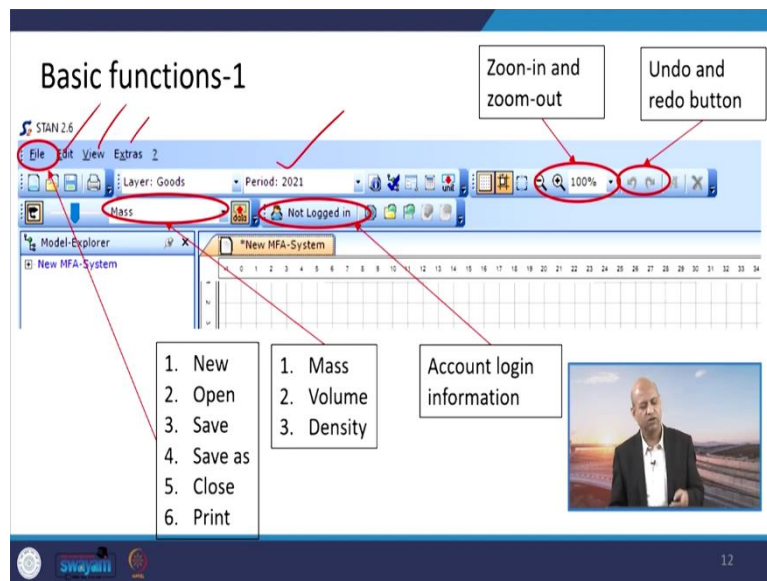
- Think about a system and create a mind map for it
- Using various symbols and connections, the desired model can be created.



11

So, this kind of flowchart you can or sample model you can make easily by using those shapes and icons. So, like export 1, import 2, import 1, process 1, flow A then process 2 then flow B. So, interconnectivity and the interaction that can be shown very easily export 2, those kind of boundary system can be seen here in a nice way.

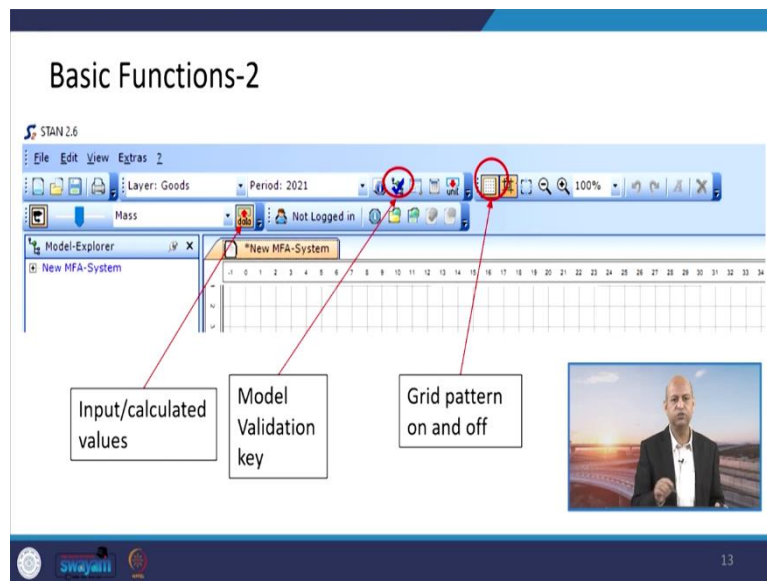
(Refer Slide Time: 06:57)



Well, this is the basic function you can see on the windows. So, it is as simple as any other windows tools you use whether Word or Excel or those kinds of file is there within file you can have the new file or you can open or you can save, save as, close those all those features are there. Similarly, related edit is there, view, extras. Then here you can see it you can choose whether mass material flow mass can be there, if it is liquid then volume maybe they are.

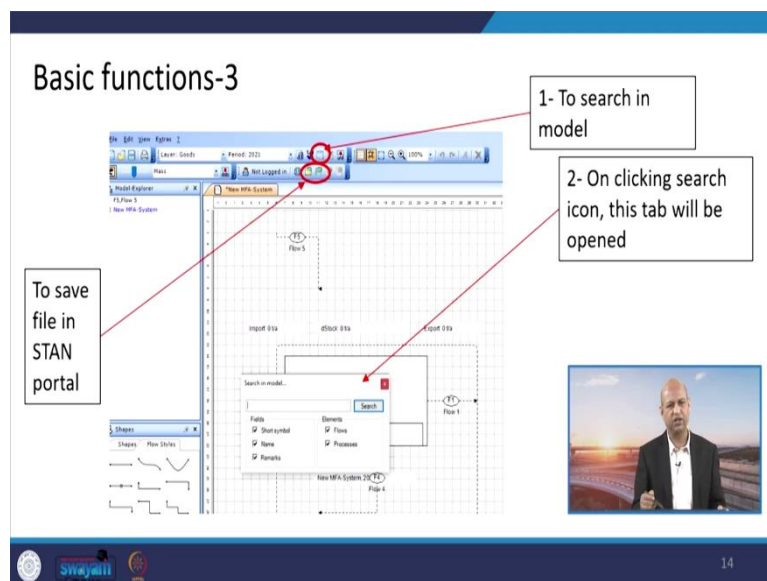
So, mass, volume or density you can choose from here. And when you log then your name will be there as user ID will be there it is not logged in so, that is why it is shown like this. Similarly, period you can choose from year 2021 or whatever year you want to use layers maybe goods or any other like services or different kinds of trades, products. Zoom in, zoom out, you can do redo, undo those kinds of buttons. So, all simple, whatever windows features are there, all those features are available here.

(Refer Slide Time: 08:01)



When we talk about like data, so, the inputs calculated values are available here you can see. Then model validation key can be seen here. Grid patterns, on and off that can be done from here. So, all these features you can see and use very easily.

(Refer Slide Time: 08:18)



Similarly, when we talk about like saving, so, these are the buttons which can be used for saving and then these different shapes are there which can be used for after you want to search for example, you have done all the kinds of things you want to search. So, there is a search button and you can see whether symbols related search or they are named related or remarks or flows all kinds of possibilities are there.

(Refer Slide Time: 08:43)

Addition of 'Process' in STAN

1- give a short symbol

2- Name the process

3- Choose process type stock or without stock

4- Fill the initial values for process

5- Click the apply

15

Then when we talk about like how to add the new process. So, for example, we have just given a randomly name because this is NPTEL course. So, we are talking about like symbol can be used NPTEL, NPTEL course sustainable. So, you can give whatever name you want to do that then mass related values volume related values all these values can be chosen from your fill, you can fill manually also and then then you can apply.

(Refer Slide Time: 09:13)

Addition of flow

1- Select flow from left bar

2- Stretch through mouse

16

So, that would be the input there you can say. Then you want to add the flow patterns. So, you can use these kinds of shapes and flow styles. So, you can put those all shapes and ultimately you can come up with a very good model, shape on the boundary layer all those things.

(Refer Slide Time: 09:26)

Addition of flow

The screenshot shows a software interface with a 'Shapes' and 'Flow Styles' panel on the left. A red circle highlights a flow style icon. An arrow points from this icon to a diagram on the right. The diagram shows a flow line being stretched across a grid. A red circle highlights the flow line, and an arrow points to it from the text '2- Stretch through mouse'. Below the diagram, a small video inset shows a man speaking.

1- Select flow from left bar

2- Stretch through mouse

Flow details 1/2

The screenshot shows a 'Flow Properties' dialog box. The 'From' field is set to '(Unknown),(Unknown)' and the 'To' field is set to 'NPTEL,NPTEL Course'. The 'Short symbol' field is set to 'F-1'. The 'Name' field is set to 'knowledge flow'. The 'Alternative text for unknown values' field is set to '0'. The 'Remarks' field is empty. A red box highlights the 'From' and 'To' fields, with an arrow pointing to it from the text '2- Fill up the details including short symbol & name'. Another red box highlights the 'Short symbol' field, with an arrow pointing to it from the text '3- Add specific remarks if any'. Below the dialog box, a small video inset shows a man speaking.

1- Go to right corner of interface

2- Fill up the details including short symbol & name

3- Add specific remarks if any

Then when we talk about different kinds of the flow details, so we need to go to the right corner and see the interface where you can see f1 for example, here you can see these f1, f1 flow 1.

(Refer Slide Time: 09:47)

Flow details 2/2

1- Click on the values

2- Fill up the values as per requirement

18

So similarly, you can give them the name and here you can get those, values like different kinds of as per requirement these values can be taken and filled in these spaces.

(Refer Slide Time: 09:58)

Putting System boundary

1- Select this symbol for putting system boundary

2- Stretch with mouse and add system boundary

19

Well, when we see the system boundary we want to make. So, here system boundary related shape is there which you can use and then as you see you when you go for a screenshot, etc. So, that we simply you can stretch and have the boundary layer within those particular activities.

(Refer Slide Time: 10:15)

Import (Input) and Export (Output) flow 1/2

For adding output flow

For adding input flow

20

Well, when we talk about like import or input and export or output related flows. So, these are the symbols or shapes like for import and for export these you can use.

(Refer Slide Time: 10:27)

Input and Output flow 2/2

Flow 1: 100±30

Flow 2: 70±5

Flow 3: 30±5

| Input values | |
|--------------|-----------|
| Mass Flow: | 100 kg/h |
| Volume Flow: | 1.13 m³/h |
| Density: | 890 kg/m³ |

| Calculated values | |
|-------------------|-----------|
| Mass Flow: | 70 kg/h |
| Volume Flow: | 0.78 m³/h |
| Density: | 890 kg/m³ |

21

And you can see your import related, export related. So, that kind of things you can add and model you can make.

(Refer Slide Time: 10:35)

Addition of text in model

1- Click on text box

2- Stretch the box as per need

Write text as per need

22

And then you can add text also when you want to define. So, text box will be there these in Windows it is very simple. So, you can stretch and type what whatever you want to see.

(Refer Slide Time: 10:45)

Flow Styles

1- Click on the flow style

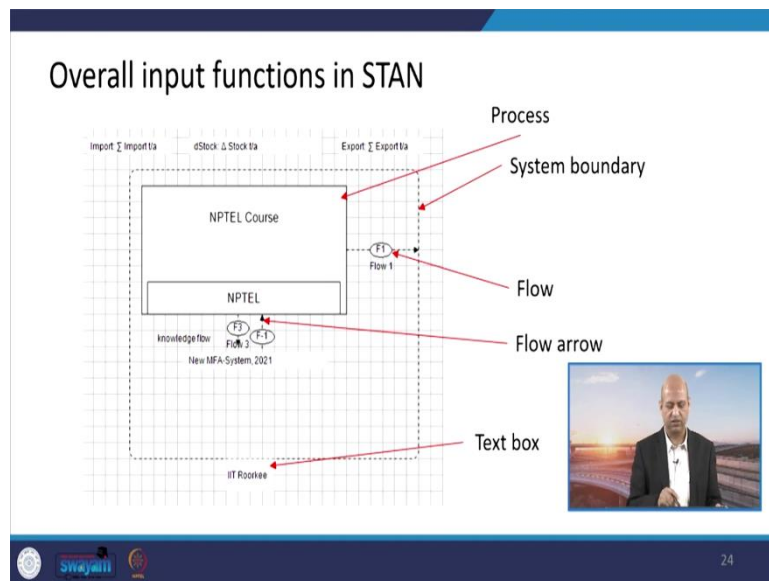
2- Select the arrow as per your model

There is no specific application of flow styles apart from representation

23

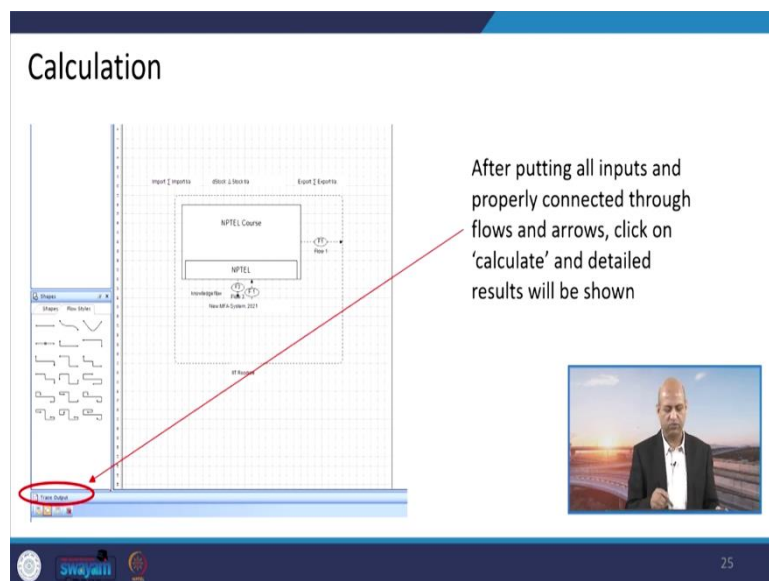
Then you want to show the flow lines so, whatever shape you want to use according whether it will go straight or it will go taking round. So, accordingly different shapes can be used.

(Refer Slide Time: 10:56)



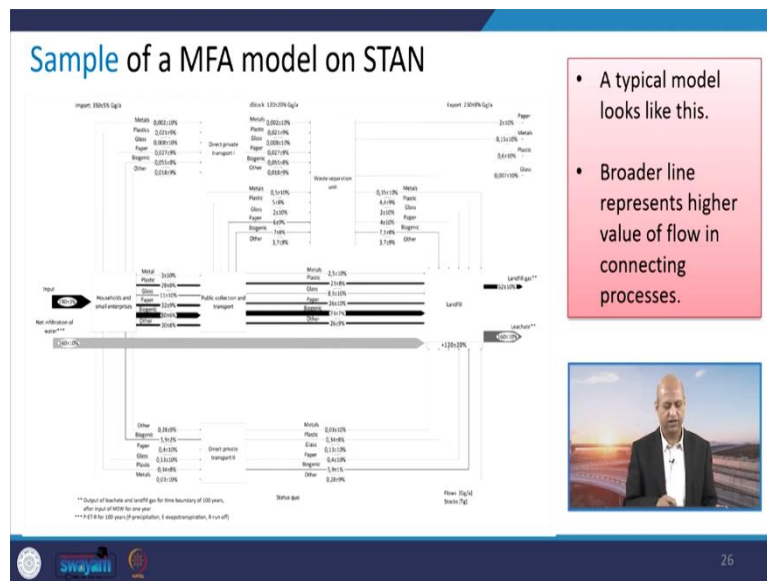
And ultimately overall input functions can be seen here. So, the flow related, process related system boundaries related all those textbox related all these things are shown here. We have used those things which we have seen in different steps.

(Refer Slide Time: 11:13)



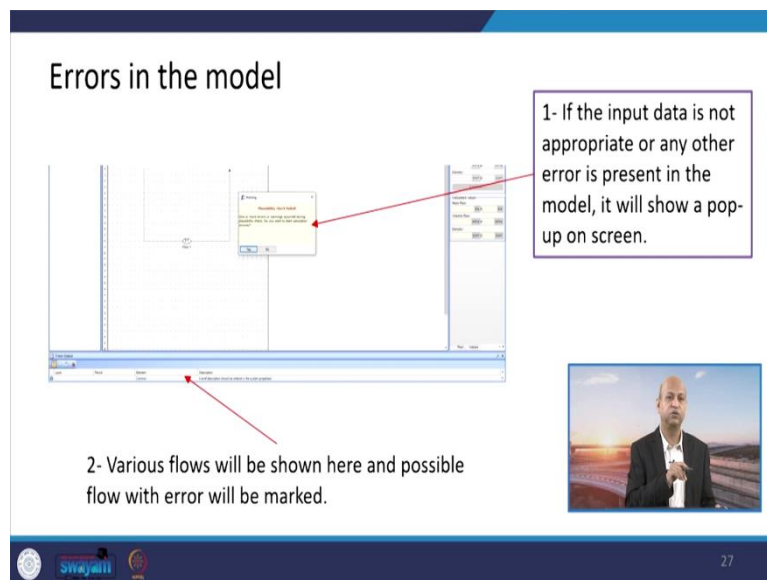
Then for calculation purpose we go here and the trace output then we can see whatever calculations are there.

(Refer Slide Time: 11:21)



And ultimately this kind of the sample material flow analysis model is created by this STAN tool and you can see different values, different names of the processes or flows and these the broader lines represents higher value of the flow. So, according to thickness of the lines may also vary depending upon their values. And this is very simple easy to read and very nice model.

(Refer Slide Time: 11:50)


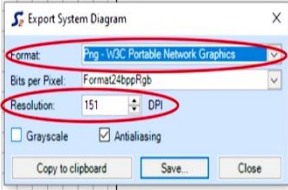


But if there are some errors then this will give like input output values are not making good balance then there will be error and this error will be shown. So, then you have to revisit and see where this error is there you can address it.

(Refer Slide Time: 12:03)

Exporting the model

- Click on the 'file'
- Go to 'export diagram' ✓
- A pop-up will be open as shown
- Choose the format
- Set the picture quality (resolution)
- Either save or copy to clipboard and paste



28

Then exports. So, you go to the file, go to the export diagram, you can see, you can change the resolution whatever resolution you want, choose the format and set the picture quality high or low. Either save or copy and ultimately, you can get that particular model and you can use it, you can save it, you can send to your teammates.

(Refer Slide Time: 12:20)


Application of STAN-MFA in Transportation Sector (1/2)

- Calculation of **resource consumption by transport** sector within a boundary

Example: Projection of material flows and stocks in the urban transport sector until 2050 – A scenario-based analysis for the city of Vienna (discussed in Lecture 37)

- Stocking of any particular pollutant in a region

Example: If lead mixed fuel is used in any state, its concentration and flows can be modelled and studied using STAN-MFA



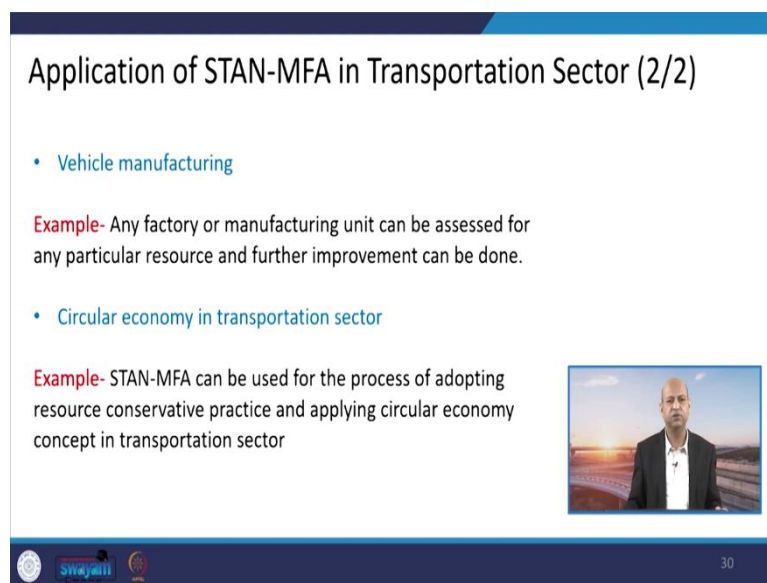
29

Well, when we talk about application of this particular tool STAN which is material flow analysis tool in transportation sector. So, basically it can be used for various aspects of the transportation system like calculation of resources consumption by transportation sector in terms of fuels or it can be also like stocks of the urban transportation sector scenario-based analysis.

For the city of Vienna which we have discussed in lecture 37. So, in that particular this particular tool has been used. Then is stocking of any particular pollutant in a region that can also be seen which because it is material like fuel is coming how much sulphur is there, how much sulphur dioxide will be produced those kinds of things can be done very simply although this is not the dispersion model.

So, do not get confused in that sense then stocking can be seen like what how much fuel is being used and different routes will be there of different buses. So, on which route how much fuel is being used those kinds of calculations can be done.

(Refer Slide Time: 13:30)




The slide is titled "Application of STAN-MFA in Transportation Sector (2/2)". It contains two bullet points, each with an example. The first bullet point is "Vehicle manufacturing" with an example stating that any factory or manufacturing unit can be assessed for any particular resource and further improvement can be done. The second bullet point is "Circular economy in transportation sector" with an example stating that STAN-MFA can be used for the process of adopting resource conservative practice and applying circular economy concept in transportation sector. There is a small video inset on the right side of the slide showing a man in a suit. At the bottom of the slide, there are logos for Swayam and a page number 30.

Similarly, like for vehicle manufacturing also you can do at the factory level or at the unit manufacturing unit level which can be assessed in particular resource consumption of a like steel sheets or aluminium parts or those kinds of things. So, when you use these and you get to know as an output some wastage so, in a circular economy you can use that wastage as a resource for another activity. So, it can be used for adopting resource conservation practices, conservative practices, and it can apply in circular economy concept for transportation sector.

(Refer Slide Time: 14:08)

Conclusions

- STAN 2 is a tool used for material flow analysis.
- A well representative model can be created of any process with multiple flows.
- Major application of STAN 2 can be done in circular economy, waste management or material stock calculations including various applications in transportation sector for resource conservation.



31

So, in conclusion, we can say that this STAN 2 is a very good tool for material flow analysis and it can be used for transportation sector also. And this will give new insights so, that we can go for decision making to you know, reduce the consumption of different resources and utilization of waste using the circular economy concepts. So, this is all for today.

(Refer Slide Time: 14:33)

References

- STAN 2 website
<https://www.stan2web.net/>
- Manual for STAN 2
[stan2web.net/NetHelp/default.htm?url=HTMLDocuments%2FContentManual.htm](https://www.stan2web.net/NetHelp/default.htm?url=HTMLDocuments%2FContentManual.htm)
- Cencic, O.; Rechberger, H., Material Flow Analysis with Software STAN. Journal of Environmental Engineering and Management 2008, 18, (1), 5

32

And these are the references where you can, download this tool and please try to play with it and learn what are different features so that you can have a new skill about using this particular tool. So, thank you for your kind attention. See you again in the next lecture. Thanks again.