Description for the general public

A stone dropped in water leads to ripples (small waves) on the water surface which move in the shape of a circle with the location where the stone was dropped in the center. These ripples continue along the surface of the water and reduce in strength before disappearing completely. If the ripples encounter a branch or edge of pond on their path, some of the waves get reflected and form another circular shape with the discontinuity at the center going radially outwards. Similar phenomenon can be generated in solid plates but on a smaller scale. Similar patterns are seen of the propagating waves. The reflections of the waves from the discontinuities can be measured and processed in order to determine the location of the discontinuities. Although in water the branch or edge of the pond are harmless discontinuities in structures the discontinuities may be cracks or other damage in the structure. A small crack or damage in an airplane wing may lead to catastrophic accident hence it is of utmost importance to check the structure regularly for cracks, detect the crack and locate them so that they can be fixed.

For this purpose airplanes and other critical structures are instrumented with sensors. The sensors convey the condition of the structure regularly. The assessment of the condition of the structure using the travelling waves is known as guided waves (GW) based structural health monitoring (SHM). In recent years optical fibre sensors have been used for GW receiving. The optical fibres are sensors as thin as hair and are very light. They do not need additional wires and hence are easy to deploy. There are sensors which look like rings and work on the same principle of constructive interference (the reason we see only few colors (not all colors of rainbow) inside a soap bubble). These ring structures can be used for sensing. The design of these rings is a complex task which needs us to take into consideration the efficiency of the travelling light as well as how light travels from the rings to the fiber and back. Also care needs to be taken to ensure that when being used as sensors, the rings do not break easily and can withstand the changes in temperature and loads which are expected in real structures.

In the project, firstly special optical fibers will be designed. As opposed to standard circular, so- called D-shaped fibers will be produced. The D-shaped fibers will provide easier access to the light-carrying core of the fiber where the circular rings can be fabricated. The D shaped fiber also helps for more of the wave to be sensed by the sensor and improves the sensitivity. The ring design has several different parameters which will be studied in detail to improve the performance. Also different shapes of the rings will be studied to improve some special abilities of the sensor. The quality of the sensors for sensing the waves will be studied in detail. The effect of direction, effect of different setups will be investigated. The reaction of the sensor to applied loads as well as under different temperatures will be investigated. The studies conducted will be with numerical models as well as experiments. Once the working of the sensor is understood in detail, we will use it for detecting damage in structures.

The special abilities of the new sensors will improve the quality of the bonding. This will be possible by decreasing the number of sensors to be used. As well as increasing the sensing range of the sensors which will make sensing very small damage possible. Traditionally the damage is detected by comparing the measurements with the measurements carried out when the structure is healthy. But the healthy measurements are not always available or are measured at completely different environmental conditions and hence cannot be compare. In order to overcome this, a method which does not need the healthy measurements is needed and is the main aim of the proposed project. The use of non-linear features is a very promising method for this reference free damage detection. The new sensors with better abilities will allow us to identify these non linearities. Also the quality of the results obtained by the new method can be further improved by placing the sensors at the correct locations.

The work within the project is on the methodology level and may find applications in several applications including airplanes, wind turbines, automobiles etc. and make these inventions of everyday use safer and more reliable.