Optical Short Course International Inc.

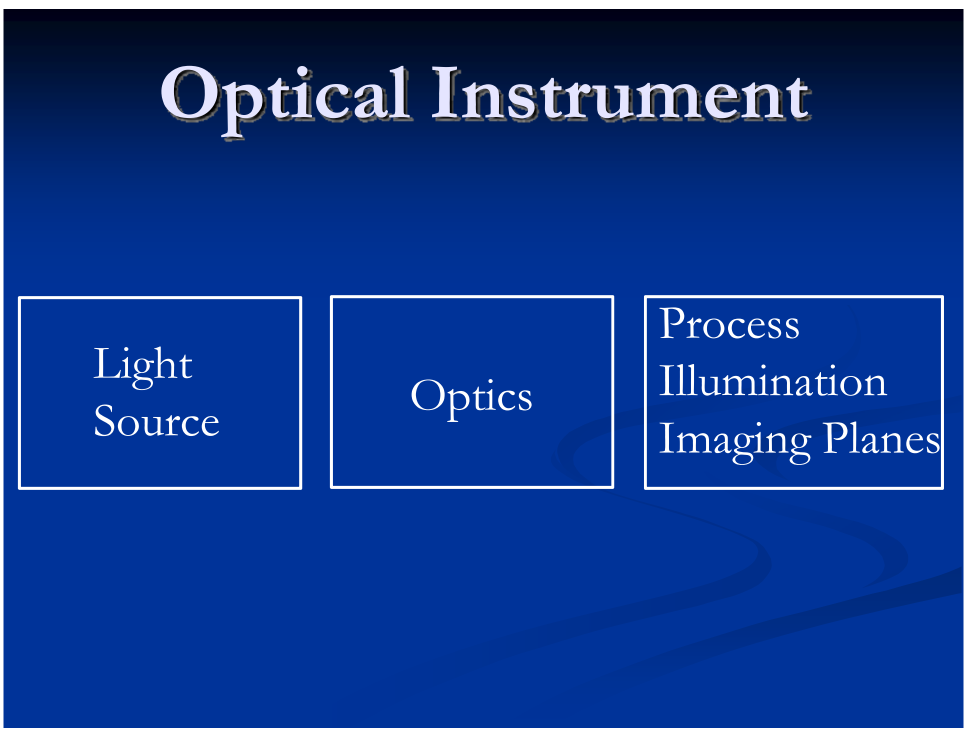
Accelerate your brain™

Troubleshooting Optical Alignment Problems

By Michael Pate, President of OSCI Inc.

The purpose of this white paper is to describe a systematic and rigorous method to troubleshoot optical alignment problems with optical systems and optical instruments. To cover the systematic part of this method, we need to think of an optical system as a light source; an optics section; and an image plane, or process plane, or illumination plane. What we will describe in this paper is how to systematically analyze each of these three major subsections of an optical system. The rigorous part of the method consists of checking in five different performance parameters for heat subsection of the optical instrument in question. If one uses this combination of systematic and rigorous parameter checking methods to diagnose optical alignment problems it will be easy to isolate the problem to a certain subsection and certain performance parameters.

An optical system can be thought of as three main subsections; the light source, the optic section and the illumination plane image planar process plane.



The light source section may consist of light sources such as the tungsten lamp HB LED, a laser or a mercury arc lamp. The light source of an optical instrument provides the signal that will be used to analyze, measure, expose, cut, probe or quantify the performance of some part or process. An example of such a light source might be a tungsten lamp in a visible spectrometer or a helium cadmium laser used in a semi conductor wafer exposure process.

For the light source in an instrument, we need to quantify several important parameters that will affect the optical alignment and, of course, the overall performance of the instrument. The five parameters that we need to quantify are:

1.) The location of the source

2.) The orientation of the source

3.) The distribution of the light coming from the source

4.) The power, watts or lumens

5.) The pointing of the source

In order to quantify the location of a light source, we need to make sure it is positioned in XYZ space with respect to some alignment fiducial. Once we are sure the light source is positioned in its original location, we can check the orientation of the light source. The performance of many types of light sources varies significantly depending on the orientation of the lamp with respect to gravity. Because of this variation, we need to ensure that the orientation of the lamp is the same as when the machine was originally aligned and verified at its last performance check.

Next, we need to check the spatial, angular, and possibly the spectral distribution of the light being emitted from the source. The spatial distribution of a light source can be checked at a particular plane along the optical axis. This is done to make sure that the distribution of light has not changed at that test position near the exit aperture of the lamp or lamp assembly. The angular distribution of a light source can be checked in several different ways to test position and near the exit aperture as well. In some optical instruments, the spectral distribution of the lamp is very important to the performance of the optical instrument. For these types of instruments, we must ensure that the power as a function of wavelength of the lamp assembly has not changed from the last time it was checked or aligned. We can check the spectral distribution of a light source by using a spectrometer to measure this parameter.

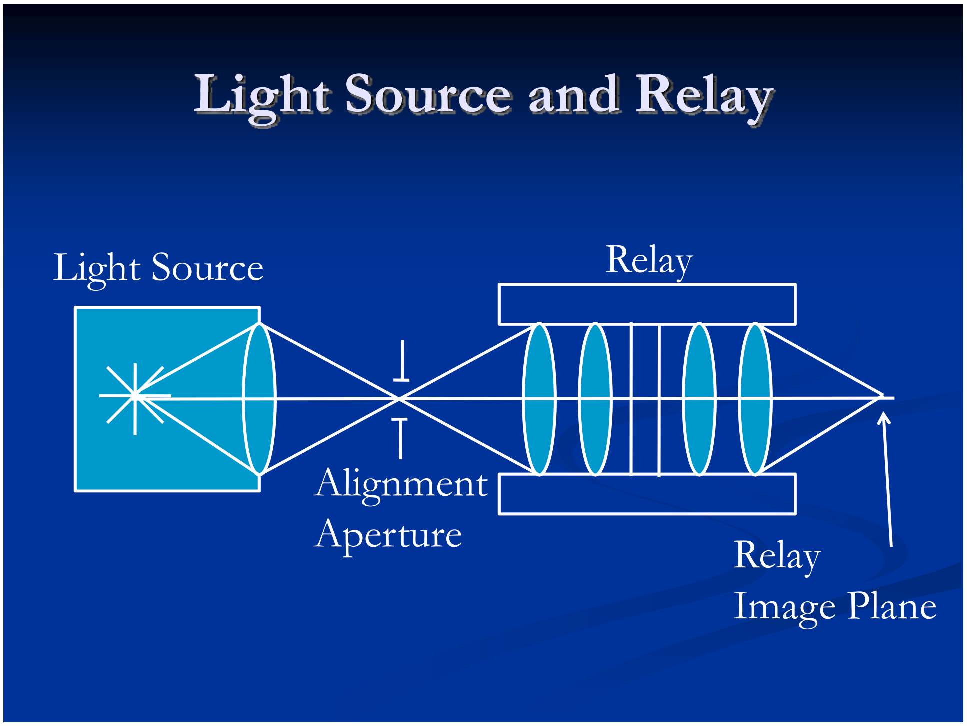
We can check the power of a light source by measuring the total power into a detector near the exit aperture or test position of a light source. Here, we can compare the number of watts or lumens the lamp is outputting through the test aperture or at the test position, to the last time the measurement was taken.

Finally, we can check the pointing of the light source to ensure that the energy from the lamp is going in the same direction as the last time the system was aligned or checked. This test can be performed by measuring the light properties at two test positions along the optical axis and compare it to the last time the system was aligned or checked.

Optics Section Tests

For the optics section of the alignment test, we need to quantify the performance before and after the optical sections are subsections and compare it to previously recorded parameters. For example, if we have a beam expander, we might need to quantify the collimation of the beam going into and exiting the beam expander. We also might quantify the beam diameter going in the beam diameter and coming out. Another example for an illumination system might be the uniformity of the beam going in and the uniformity of the beam coming out.

So, in order to quantify the location orientation distribution power and pointing of an optical subsystem, we will usually have to quantify these parameters both before and after the optical subsystem. We will then need to compare the quantified parameters to the values they had the last time the optical system was aligned. An example of a location alignment check is an optical alignment target which lies on the optical axis of a relay optical subsystem. We would locate the image of the axial beam in XYZ space. For orientation, we would need to make sure that the image was right side up and left or right reverted correctly. This ensures there are no problems with the optical relay quantify the spatial distribution of the light at the spot size in the image plane of the relay. To quantify the power or the optical transmission through the relay, we could measure the power of the beam going through the alignment aperture and the power of the beam in the image plane of the relay and compare it to previously known values of transmission. And finally for pointing, we could measure the angle of the center ray of the relay both before and after the image plane of the relay to ensure that it was co-aligned with the optical axis of the instrument.



Illumination Image for Process Plane

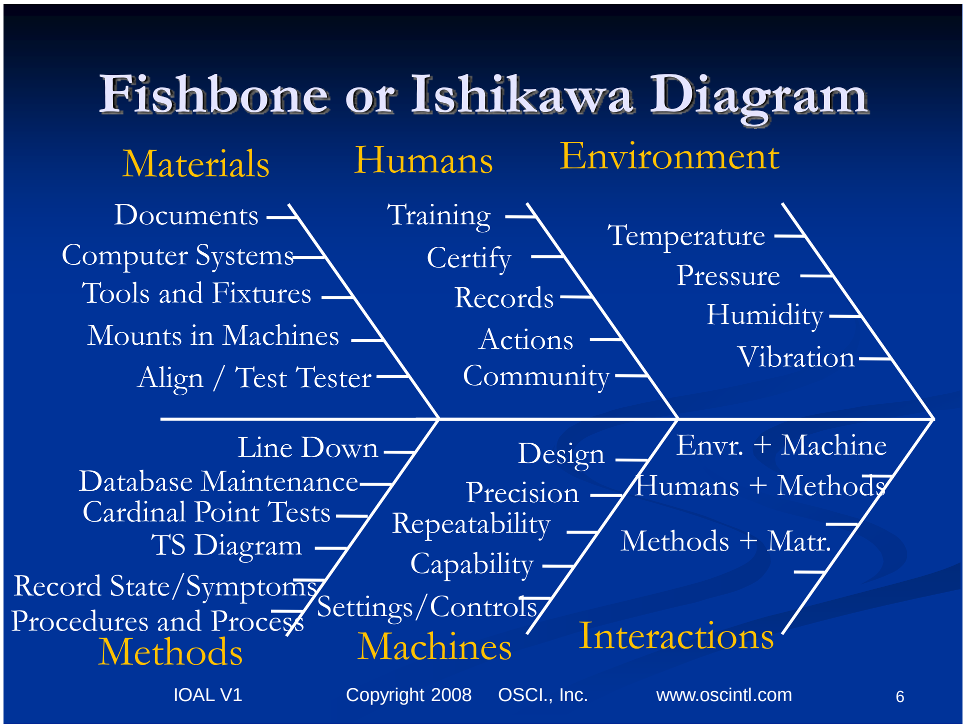
In order to quantify the performance of an optical instrument at the illumination in imaging or process plane, we need to perform some alignment checks at these planes. The parameters we will verify at these planes are the location, orientation, distribution, power, and pointing. For example, if the optical instrument is used to cut plastic with an infrared laser, we will need to check the location of the laser beam when it is focused on the process plane to ensure sharp precise cuts of the plastic material. In this case, we would check the location of the beam in XYZ positions where the material process stages are located at their known positions. We can do this check using many of the tools described in OSCI's *Introduction to Optical Alignment with Lasers* (*IOAL*) DVD course. For example, we could use a knife edge test, or we could cut a test part and measure its location with respect to a stage alignment fiducial. We can verify the orientation of the cuts in the same way by inspecting the cuts with respect to an alignment fiducial. If the laser beam is scanned during the cut, we can check the spot size as a function of its spatial distribution in this process plane. We can also check the power in the beam as a function of scan angle or spatial position in the process plane and compare these power values to previously measured values when the machine was last aligned. We can also check the pointing direction of the incoming laser beam at the process plane to ensure that the beam is at 90° to the process plane so that when we cut the polymer the kerf's in the material is symmetrical.

Optical Transmission Checks

Optical transmission checks performed throughout the complete optical systems is another key troubleshooting technique often used by optical alignment engineers to diagnose problems with an optical instrument. An optical transmission check is performed by recording the optical power before and after every optical component in a system. If we perform an optical system transmission check at periodic intervals during an instruments use, we can quickly compare the previously recorded values to the current state of the machine. If we chart the optical transmission at these different fiducial locations throughout the optical instrument, we can easily predict the failure of a certain component as we watch its optical transmission drop over time. Or if we see a drastic change like a step function from one shift to another, or one day to another, or one week to another, this is typically a simple signal that something has happened at a particular optical component within a system.

Once we see that a drastic change has taken place, we can focus our diagnostic efforts at this location in the system or somewhere downstream toward the process plane. These optical transmission checks are very useful as predictive maintenance tools and are thoroughly discussed, along with their benefits, in one section of the *IOAL* DVD course.

Fishbone diagram



In the *IOAL* DVD course, we discuss the Fishbone or Ishikawa Diagram as another troubleshooting tool to help diagnose optical alignment problems. The Fishbone Diagram is tools to help an individual, team or organization follow a structured method to locate potential optical alignment problems. It organizes potential alignment problems into six groups. The six groups are: materials, humans, environment, methods, machines, and interactions. For example, in the human section we can ask 'Are the technicians and engineers trained properly in optical alignment? Are they certified to the correct level in optical alignment procedures on this machine? Have they been keeping proper records of the state of the machine and the instruments used to align this machine? Have they recorded the actions taken to diagnose and rectify the optical alignment problem with this particular machine?'

The Fishbone Diagram can help a group analyze where problems might be coming from or why problems might exist with the optical alignment of a particular machine or group of machines. The Fishbone Diagram can be very useful tools to help groups identify problem areas one might not have considered during stressful and pressure filled meetings, when trying to find solutions to difficult optical alignment problems.

OSCI Inc. has come up with a solution individuals who need optical alignment training—the *Introduction to Optical Alignment with Lasers* DVD course. This white paper is a very small sample of some of the things one might learn watching this 10 1/2 hour DVD course on optical alignment techniques, skills and processes. Because of the need, we also teach live classes with practical laboratory alignment applications at fixed times and locations throughout the year or we teach in-house classes at your facility, around the world. Or we can create custom private specifically for your company and will help you develop a custom syllabus that meets your specific needs based on your machines and the skill level of your technical professionals. We also participate in optical consulting in the areas of optical instrument troubleshooting, optical alignment problem diagnosis, lens design, reverse engineering and alignment tools. We have a team of world-class optical professionals to help quickly discover and rectify your optical alignment problems. Please give us a call so that we may discuss your optical needs!

info@oscintl.com

541-255-2165

www.oscintl.com