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# Commemorating Ten Years Operation of the Indonesian Low Speed Tunnel (ILST)

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***Abstract :*** *The Indonesian Low Speed Tunnel (ILST) commissioned in 1987 is a closed circuit one with a working test section of 4 x 3 $m^2$ and 10 m in length which is a combined of two: front and rear test sections. The upstream part has a length of 5.75 and the downstream one is 4.25 m. In total four arrangements can be made, and it is moveable on a transverse rails. The tunnel has a nominal speed of 110 mps.*

*There are two balances facilitating force measurements: external and internal balances. Four possible model attachments are provided enabling either two or three dimensional tests(2-D, half- and full-models) or non-aeronautical test. These are central and wire struts, sting support and turn tables, which gives more testing flexibility to ILST.*

*Following the conducted test section calibration with and without model in 1988, ILST has been actively involved in supporting the development of the national aircraft industry (IPTN). Three main aircraft models, namely the configuration of basic and development of CN-235; the configuration of basic and development of N-250 and also the preliminary design of N-2130. Those have been carried out and occupying the activities at the ILST in the last 10 years*

*In addition to that, several in house and cooperative research activities in conjunction with national and international research institutes, aircraft industries as well as university like IPTN, Fokker, BOEING, NLR-the Netherlands, NAL-Japan, TU Delft have also been conducted. This paper reviews the ILST activities within the last 10 years in operation.*

## 1. Introduction

The Indonesian Low Speed Tunnel (ILST) is a closed circuit, atmospheric and low speed tunnel with a working section of 3 x 4 m. The establishment of it is intended to fulfill the need to support the development of national aircraft industry called Nusantara Aircraft Industry (IPTN). The ILST represents the biggest, if not the most sophisticated, wind-tunnel in Indonesia.

The development of the ILST follows the agreement made between the Aero-Gasdynamics and Vibration Laboratory of the Agency for the Assessment and Application of Technology (LAGG-BPPT) with NLR* for the realization of a Low Speed Tunnel at the National Center for Research, Science and Technology (PUSPIPTEK), Serpong. The ILST project development started in 1979. During its design phase, extension of its capability for non-aeronautic testing purposes was considered.

This paper reviews the past ILST's activities after 10 years operation. A brief explanation of the ILST facility will be given in Section 2. Section 3 discusses measurement activities also cover research and development ones. Finally, the concluding remarks are given in Section 4.

## 2. ILST Facilities

The ILST is a low speed, atmospheric and of a closed return tunnel. Its configuration is essentially similar to the aerodynamic layout of the German-Netherlands Wind-tunnel (DNW) located at Emmellord, the

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Netherlands.

The test section is 4 x 3 [$m^2$] a half size of the DNW. The aerodynamic layout of the ILST is presented in Figure-1.

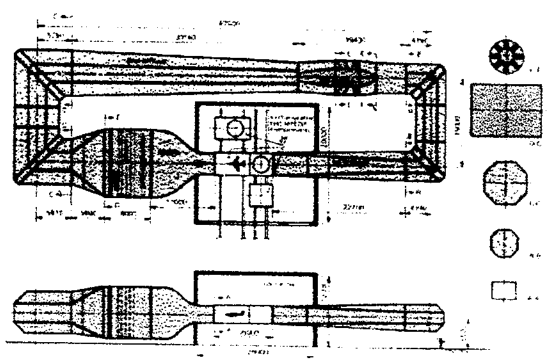

Figure-1 Aerodynamic lay-out of the ILST

The test section comprises of two front and two rear parts. The front parts have a length of 5.75 m. Whereas the rear ones are 4 m long. Thus, there are 4 possible lay-out arrangements. One of the upstream parts is furnished with a six component overhead balance and a synchronous turn-table. The other one is only provided with 2.7 m diameter turn table. A sting support system is inserted in one of the downstream part. And, the other rear part contains a simple turn-table which is the same as that of the empty upstream one.

The test section diffuser, the first cross leg and fan diffusers have an area ratio of 2, 1.318 and 2.5, respectively. The aerodynamic design of the corner vanes is the same for all corners, e.g. the same chord length and pitch/chord ratio of 0.2. To guarantee man access into the tunnel circuit, the pitch is made approximately 35 cm. Upstream of the second corner an FOD is attached and consists of 2 inch mesh steel safety screen. The fan is supported by eight bladed fan. Its maximum fan speed is 400 rpm yielding a nominal speed up to 90 m/s in the test section consuming 1900 KW. Detail of chronological explanation of the establishment of the tunnel is described in reference [1].

After the tunnel first completion in 1987, the calibration of its empty tunnel was carried out [2]. The result shows that the turbulence level is achieved in the range 0.1 %. Its flow angularity is less than 0.1 degrees. Furthermore, the axial static pressure distribution is within ± 0.2 %. The temperature deviation in the test section reaches about ± 0.5 centigrade due to the cooling system in the heat exchanger facilitated by water at 0.125 kg/s .

The Data Acquisition and Reduction System (DARS) consists of four computer systems with the following functions : Data Acquisition (HP 1000); Data Processing (HP 9000); Tunnel automated control (HP 1000); and Test preparation and Post Processing (HP 9000). The HP-9000 configurations was a product of refurbishment of DARS taking place in 1995 following requirement for slipstream propeller and flutter tests to post process dynamic data. Those data could not be accommodated within the past HP-1000 system.

The data sampling rate is 20 per second, and is supported by 60 self contained conditioning units. As much as 1000 pressure taps can be accommodated at once by using common scannivalves. On- and off-line processing can be done simultaneously. The on-line processing gives intermediate results which offer possibility to control test results and procedures.

Formerly, the development of DARS software involved LAGG personnel as part of the man power training. In house development done by LAGG personnel has produced a more integrated system called LAGG-net in which all LAGG is integrated in a net-work system.

The ILST facility is also provided with a compressed air system. This facility is linked to the test section with a piping system enabling supply of a clean and dry compressed air at 60 bar out of 200 $m^3$ storage vessels. This air can be used to control boundary layer blowing or to drive turbine powered fan simulators or rotor drives, etc [3].

## 3. Testing Experiences

Testing activities in week occupancies from 1988 till 1997 is summarized and presented in Figure-2. Activities such as empty calibration, measurement of sting interference, investigation on the support for turbine power simulation as well as joint research are classified within research activities

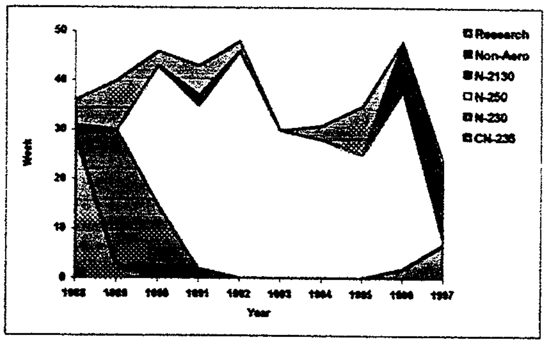


Figure-2 Tunnel occupancy within 10 years

In fact, there are two main categories of research activities at the ILST, these are : in-house and cooperative researches. A few years ago, in-house research activities with respect to wall interference and support interference and its correction had been carried out. Examples of repeatability check of sting support performed in 1990 are presented in Figure-3 for alpha polar[4]. The model used was the N-230 aircraft type the development of which was preceding the N-250 type.

Furthermore, measurement techniques are also developed to improve operational efficiency and to up-grade man power on the testing capability. Lift force calculation of 2-D model using pressure walls is one of the examples[5].

The first joint research activity was carried among IPTN, BOEING and NLR on high lift devices. The main objective of the test was to study high lift devices. Airfoil in its half model configuration completed with flap and slat at two different angle positions mounted on the external balance. The results were found to be comparable with theoretical calculation. The use of slat and flap increase the maximum lift[6]. The third phase of this cooperative research had been completed in November 1997.

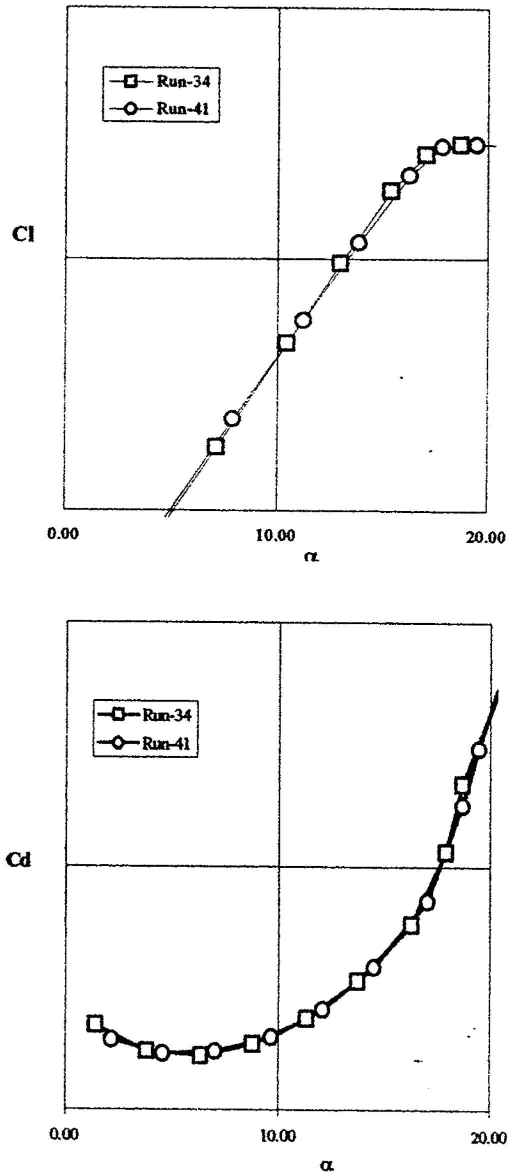


Figure-3 Repeatability test results

A typical experiment concerning the effect of propeller slipstream phenomenon was carried-out in March 1995 as part of a joint research activity together with IPTN, Fokker, NLR, TUD and ITB. The main objective was an exercise for thrust and drag book-keeping as to understand the influence of slipstream effect on aerodynamic force of the model. A typical half model was used and attached to the upper floor and connected with TPS system. In this experiment a Rotating Shaft Balance (RSB) developed by NLR[7] had been installed inside the nacelle supplemented a six component external balance available. The RSB installed was mainly used for knowing the pure thrust of the propeller. The propeller installation was identified to contribute lift as much as 18 % at the position where overall lift is one and trhust coefficient was 2.5. Moreover, it was also clear that slipstream has a stall delaying effect due to the fact that the curve of lift remains liniear to higher angle of attack at the same thrust coefficient[8].

In addition to that, in-house numerical study has also been carried out using VS-AERO to simulate the propeller slipstream effect based on the same model[9].

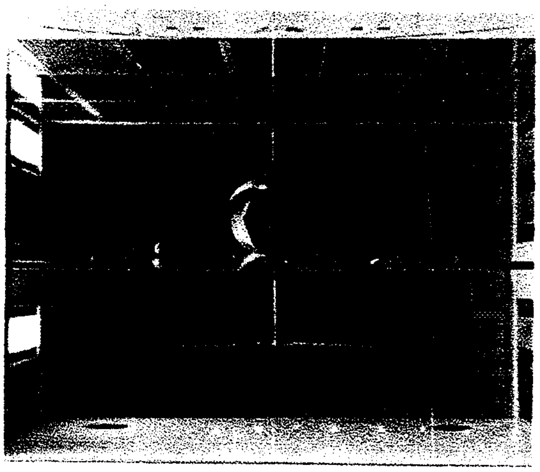

Figure-4 CN-235 model mounted on the wire struts

Non-aeronautical tests were minor one which took only 5 week occupancies in total within ten years activities[10,11]. The reason was caused by the fact that most testing capacity was allocated and dedicated for aeronautical testing especially those from IPTN. Moreover, people here still views that it is a redundancy to have non-aeronautical geometry such as building, cars, etc. tested in the wind-tunnel. The last non-aeronautical test performed was for the model of a suspension bridge planned to be built at neighboring area[11].

Soon after its completion in 1987, the ILST was calibrated using 1 : 10 scaled-down CN-235 model, the first Indonesian made commuter under the cooperation with CASA-Spain. Somewhat smaller model (1 : 12 scaled down CN-235) had been tested before at NLR-LST during its design phase[12]. The model mounted on the wire-struts is presented in Figure-4.

Figure-5 N-250 model mounted on central strut

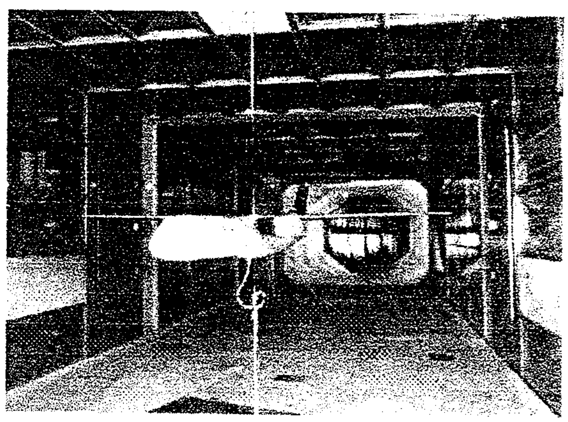

Figure-6 N-250 Flutter model

The objective was not only to observe the tunnel for aeronautical testing purpose but also to train LAGG staffs for running routine tests as well as to check the DARS. Force and moment measurements were taken. Results were compared with those obtained

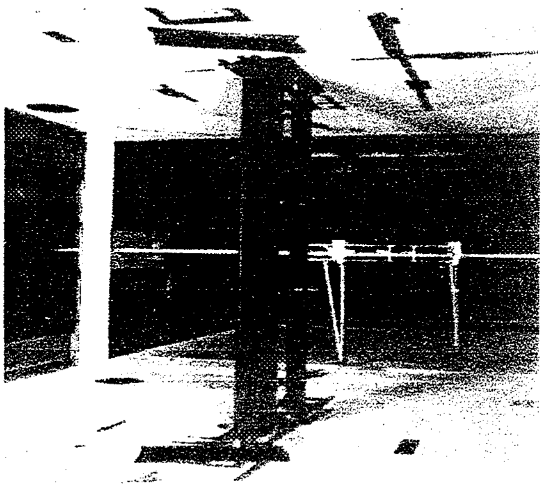

Figure-7 N-2130 2-D model

at NLR-LST. The results of this calibration was re-emphasizing data obtained at NLR-LST low speed tunnel. Reasonable agreement on aerodynamic forces as well as pressure distributions were obtained between NLR results and those of ILST [13].

Subsequently, the ILST has been successfully used to support the national aircraft development conducted by the Indonesian Aircraft Industries (PT. IPTN). Three aircraft models namely the configuration of the basic and development of CN-235, the basic and development of N-250, and the preliminary design of N-2130 have been investigated at ILST.

By the time the ILST started operation in 1988, the CN-235 development had entered the flight test program. Subsequentially, testing activities were devoted to new products development that is N-250.

Prior to the development of N-250, a study had been performed on the development of a smaller model called N-230. However, the study had been stopped and N-250 seems to be more potential to IPTN analysis. This is visible from Figure-2 that in 1990 and 1991 both type of aircraft has been thoroughly studied. Following years had been occupied by the development of N-250.

During the development of N-250, ILST had acted as the main facility to support the program. Within the last five years test on N-250 is representing major activity in the ILST (see Figure-2). Approximately 120 weeks of wind tunnel test time have been dedicated for N-250 as compared with CN-235 which is only 9 weeks and N-2130 which occupies 23 week occupancies in total. Approximately 7500 wind-tunnel hours have been spent for the development of N-250 aircraft during its design period.

Testing activities of those aircraft models include: 2-D airfoil pressure measurements, propeller simulation on full configuration of aircraft model as well as half-model, ground board test for take off and landing simulation, half model testing for high lift devices, flutter test, to say several.

However, most of tests are performance and steady type. Unsteady test like flutter or other aeroelastic test was only done twice in 1993 and 1996 for 3 week tunnel occupancies in total. Figures 5 to 7 show example of testing configurations.

## 4. Concluding Remarks

ILST testing activities within the last ten years has been reviewed. Apart from in-house and joint research testing activities, the ILST has acted as the main facility for the National Aircraft Industry to test its new product development during design phases. Several types of aircraft models have been tested following the ILST completion in 1987, namely CN-235, N-230, N-250 and the development of N-2130.

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