

Project Title: Integrated Approach for Development of Process Models and Pilot Production of Aluminium Alloy Extrudates using Porthole Dies (S-20)

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Objective :

The aim of the project is to provide end to end technology solutions for small medium enterprises for manufacturing of critical extrusion profiles. Currently, critical extrusion profiles are developed based on implicit knowledge of shop floor personnel that requires number of trial runs. In order to improve productivity and time reduction in design and development of profile, the project was executed with the following objectives.

- a) Flow stress data generation for various grades of aluminium alloys at different strain rates and temperatures.
- b) Development of process models for aluminium alloy extrudates based on flow stress data, numerical simulation and press trials
- c) Pilot scale production of extruded components

All the objectives have been achieved in this project.

Background :

The complex interaction of process parameters and die geometry determine the product quality aluminium extrusion. The key to produce defect free profiles is to closely control metal flow and dimensional variability of profiles. In shop floor, die design is largely dependent on empirical design rules based on trial and error methods which is time consuming and cost intensive. Port hole dies are being popularly used for production of hollow aluminium profiles.

But the construction features and geometry factors are many to control the variability in metal flow. In India, extruders limit the number of process variables and concentrate on high volume production. In India, the knowledgebase is limited as the applications are yet to pickup certain high technology areas such as automobile and aerospace sectors. With increasing demand and complexity of profiles used in sectors such as automobile, body bumpers, condenser tubes and other structural parts are made of extruded profiles. The parts needs to be produced with close dimensional tolerances and high quality that requires proper designing of dies and good control of process

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parameters to achieve better quality product and meet the customer requirements. In this regard, the demand for complex thin walled profiles is expected rise and automobile and building & construction sectors expected to be growth drivers for extruded profiles in the near future. Hence, existing methods of trial and error methods of die design needs to be modified and there is a requirement of scientific approach to address complex profile design. Process model development using numerical simulations will benefit industry in terms of productivity, time consumed for die modifications, product quality improvement and achievement of tighter tolerances demanded by the applications. Several laboratories have worked in this direction but the outcome of research and data generated are inaccessible in the public domain as the respective laboratories/ industries keeping the knowledge as commercial secret. Hence, this project was taken up as to provide technological solutions to Indian aluminium extruders as a national facility. An Extruders meet was conducted in April 2015 at the start of project to understand the requirements of customer and also another meet is planned in December 2019.

Outcome:

Technical knowhow /output

Knowledgebase of developing port hole die designs for various aluminium alloys. The design algorithms have been validated on different capacities of extrusion presses with different container diameters and it was proven that the algorithms have produced the desirable profiles in the first trial itself. This knowledgebase will be exploited in generating revenue for the centre. Various feasibility reports have been generated as a part of business plan. Ordnance Factory, Ambajhari, Nagpur and Jindal Aluminium, Bangalore (One) and also for Sagar Asia Pvt. Limited, Hyderabad.

Infrastructure developed include facilities for

- Flow stress data generation:
- Dedicated hardware/software (DEFORM 11.1) for extrusion simulations
- 1400 Ton extrusion press with other auxiliary facilities such as billet loader, furnaces, inline quench tank etc
- The press has features such as isothermal extrusion, isobaric etc
- Flow stress data generated for various aluminium alloys i.e AA6063 , AA6082

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Important Results:

- Hot compression tests carried out on AA6063 and AA6082 and for flow stress data and the same were used for numerical simulations
- Generic tube profile of 2mm thickness validated on a 450 ton extrusion press using AA6063 alloy indicated profile exit temperature 500°C comparable with simulations 534°C. The peak load from simulations was 245 Ton and at press was 240 Ton. The same is comparable with analytical calculations 225 ton. Extruded profile indicated straightness i.e., without any bending or twisting and the design was successfully validated.

Simulation studies and Validation trial on Electrical profile

- A complex electrical profile from extrusion industry was validated on a 1600 Ton extrusion press using AA6063 alloy. Industry design with four port holes could not achieve metal flow balance.
- Systematic die design modifications taken up and design was modified to six portholes alongwith pocket.
- The extruded profile with the modified die design indicated straightness i.e., without any bending or twisting.
- The product exit temperature obtained through simulation (551°C) closely matches with the temperature measured at press trials (532°C).
- The peak extrusion load recorded on the press was near to the load predicted by simulation studies

Simulation studies and validation trial on Multi utility profile

- A multi utility architectural profile was validated on a 1600 Ton extrusion press using AA6063 alloy. The extruded profile indicated straightness i.e., without any bending or twisting.
- The extrusion load recorded on the press was 961 Ton and is closer to the value obtained in simulation studies, 920 Ton.
- Product exit temperature obtained through simulation (537°C) is in good agreement with the temperature measured at press trials (520°C).

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Simulation studies and validation trial on architectural profile

- An architectural profile was validated on a 1600 Ton extrusion press using AA6063 alloy. The profile was successfully extruded in the first trial itself and the profile was straight, and no deflection observed.
- The product exit temperature obtained through simulation (519°C) is in good agreement with the temperature measured at press trials (510°C).
- The peak extrusion load from simulation studies was 1160 Ton and it is comparable with 1078 Ton recorded in the press trial

Simulation studies on other profiles

- Numerical simulation studies received from Vikram Sarabhai Space Centre (VSSC), Trivandrum, Ordnance Factory, Ambajhari, Sagar Asia Pvt. Ltd., were carried out. These profiles were taken up for feasibility studies in order to validate the die design guidelines generated in the tube profile. These profiles will be validated at JNARDDC press facility.

Awards/ Honours received:

The research paper publication received prize for the in the International Conference and Exhibition on Aluminium '**INCAL- 2019**' held at Bhubaneswar,30 Jan -2 Feb, 2019

Results of academic interest

Technical papers presented

- I. Port hole die design by numerical simulations for aluminium extrusion, at ALEX, Mumbai , October 2017
- II. Aluminium extrusion die design by numerical simulations and case studies, , Development of Aluminium Alloys & downstream products for Defence, Aerospace & other strategic applications jointly organized by Jawaharlal Nehru Aluminium Research Design & Development Centre, Nagpur and M/s Corporate Monitor at JNARDDC, Amravati Road, Wadi, Nagpur February 23-24,2018
- III. Role of dies & tooling in development of new alloy products/ profiles in aluminium extrusion, One Day National Seminar on Development of Special Alloys and Composites of Aluminium for New India by AAI on 16 March 2018 at Mumbai.
- IV. The effects of split ratio on extrusion pressure in a generic tube profile of AA6063 using porthole dies by numerical simulation ,One day Conference on Extrusion Dies and Tooling Pune 25 July 2018.

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- V. Die design for generic tube profile using port hole dies, 6 September 2018 at International Bauxite, Alumina, Aluminium Conference & Exhibition, Mumbai, India

Thesis guided:

Extrudability of Aluminium Alloys by Hot Compression test in collaboration with VNIT, Nagpur, 2015

Intellectual Property rights

- Die Design-copyrights under process